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THROUGH THE EYES OF THE EDITOR

G. E. Tilton has written an article on impressions which should appeal to the general practitioner. He has recognized the problems they face and has explained some of the misunderstandings regarding impressions. The technique he suggests divides attention between the impression base and the denture periphery. By means of this separation of two phases of the problem, he has simplified the procedure and the understanding of impression building.

R. H. Kingery has discussed centric relation in such a way as to eliminate much of the confusion which has surrounded it. He has broken it down into its component parts and has analyzed each part in relation to the other. He recognizes centric relation as a three-dimensional relationship of one jaw to the other. He describes it as the horizontal relation of the mandible to the maxilla *plus* a vertical relation which is critical because of the displacement of tissues in a vertical direction. He also distinguishes between centric relation which is a relation of the jaws to each other and centric occlusion which is a relation of the teeth to each other. He emphasizes the fact that centric occlusion of the teeth must occur when the jaws are in centric relation.

Ralph H. Boos lists seven procedures which may be used in adjusting the articulation of teeth. These procedures place an adequate emphasis on the need for an accurate diagnosis. Following the diagnosis, each of the procedures is discussed, along with indications for its use. The proper choice of treatment is equally important to the treatment itself. The establishment of the centric relation of the jaws is essential to success in treating occlusal disharmony. We agree that the term "opening the bite" is misleading and that "increasing the vertical dimension of occlusion" is more accurate and meaningful. The writers on prosthetics should strive to eliminate the slang expressions from prosthetic literature and arrive at terminology which is accurate, concise, and unmistakable in its meaning.

Charles H. Moses recognizes the existing confusion on the subject of articulation, and he approaches the problem from a number of angles in an attempt to bring about a clarification. So the reader can follow his thinking, he is careful in defining the terms he uses. This is in recognition of the fact that the terms used in discussions of articulation have different meanings to different people. In order to develop a background for his discussion, the occlusions of various groups of animals and of primitive people are studied. From this study, he shows the relation between occlusal form, muscle, bone and joint development, and function.

Much of the discussion revolves around the Monson curve and the anti-Monson curve. The development of the anti-Monson curve from an occlusion which started out with a Monson curve (curve of Spee) is at-

tributed to wear resulting from the relative tooth positions rather than from the chewing cycle. We believe that both factors are involved. It is interesting to note in this connection that the amount of glide of one set of teeth over the other increases as the cusps are worn away. This leads us to wonder if more lateral thrust is delivered to ridges by teeth which require a greater amount of glide over each other for efficiency.

The problem of the hinge axis of the mandible is discussed, and some experiments are shown to prove that the mandible *can* open with the condyles remaining in their fossae. While the experiments show what they were devised to prove, they do not prove that the jaw functions in this manner.

An interesting series of experiments are reported which show that the pitch of the occlusal plane (Monson or anti-Monson) is determined by the relative position of the arches. Occlusal planes with opposite curves were developed on an articulator with the same guidances. This seems to raise the question of the validity of the functional chew-in path as a guide for the occlusal plane.

Victor H. Sears has described his present specifications for artificial posterior teeth. This is the second of a series of three articles about posterior teeth which he has written for the JOURNAL OF PROSTHETIC DENTISTRY. He believes that the form of the occlusal surfaces of these teeth should be designed with a definite objective for each of the parts, and he recognizes the need for further thought and development of their specifications. He makes some interesting suggestions, particularly as to the reduction of occlusal contacts on the working side and as to the means for developing balancing contacts for the various protrusive occlusions. The occlusal forms of the balancing teeth should be of especial interest to those who use modified tooth forms.

J. E. Scott states that the objective of his system of full denture construction is the correlation of the mechanics of the articulator with the anatomic movement in the temporomandibular joint. His background discussions are replete with complicated terminology and references to physical and biologic principles which seem to have little relation to the procedure he describes. He feels that the procedures taught in dental colleges should be standardized. This is not necessarily a desirable objective since there is need for variation in order to progress and since there is no standardization of operators or patients.

The equipment described is very ingenious and some of it may have some value, but some of it is too arbitrary to be used without judgment. The bite plane leveler is a complicated instrument for locating the occlusal plane. The guide points are all external and, apparently, the intraoral ridge relations are ignored. The face meter is used to establish the vertical dimension. We question the validity of the formula that is used for the establishment of this dimension. It ignores the physiologic rest position and the variations in the physiognomy of patients. He does emphasize the importance of maintaining the established vertical dimension after the casts are mounted, which is good. The cuspid nose meter is used to select the size of the teeth. This could be open to question because of the variations in tooth sizes in different patients. It seems to us that more of the operator's judgment should be used. Also, the natural tooth size of the individual patient should be used when this information is available. The use of the Gothic arch tracer is questioned only because of the way in which the centric relation record is made. The stylus being locked in a hole in the tracing table can contribute to lateral displacement of the baseplates on the ridges. The rotary point finder is a combination kinematic face-bow and graphic condyle path recorder. It would be capable of accurate registrations. These measurements do not seem to be used accurately as they are adjusted to the articulator, since this adjustment is made by averaging the recordings of the two sides.

The articulator is so constructed that the lower member moves instead of the upper member—as is customary in the conventional articulators. It seems to us that it makes no difference which member of the articulator moves provided the movements are

duplicates of those of the mandible in relation to the maxilla while the teeth are in contact. The lower element of the milling machine also moves while its upper member is held stationary. The motions of the grinding machine do not seem to be as well guided as those of the articulator. It seems to us that they should at least duplicate the movements of the articulator. The entire set of equipment shows the results of much thought and ingenuity on the part of the inventor, but we doubt its accuracy at many points.

F. A. Peyton, J. P. Leibold, and G. V. Ridgley report their research on the hardness of indirect die stones. Their work is particularly timely because of the current interest in the hydrocolloid techniques of fixed prosthesis. The results indicate that the improved stones are superior to regular stones for use as dies for indirect castings, and that immersion in oil does not improve the resistance of stones to abrasion.

Ralph W. Phillips and Ben Y. Ito report the results of their research on the factors which affect the surface of stone dies poured in hydrocolloid impressions. They have examined the effects of variations in techniques from the preparation of the impression material to the treatment of the finished die. Then they describe the procedures which they found would produce the best surface on dies. This work should help to solve some of the difficulties encountered in the hydrocolloid technique for fixed prosthesis.

Robert M. Appleman emphasizes the importance of close cooperation between the prosthetist and the surgeon in rehabilitating patients by means of surgical prosthesis. Surgeons are most happy to have the prosthetist's assistance when they know what can be done for their patients after malignancies have been removed. The restorations can best be made if the prosthetist is consulted before and during the surgery. The cases described illustrate the need for skill and the ingenuity required in this phase of prosthetic service.

Daniel B. Torn has described the mechanics of speech of cleft palate patients and the causes of nasality in their speech. Treatment of the palate may be either surgical or prosthetic. Prosthetic treatment of cleft palate patients is more effective if there has been no surgical interference. The examination for and the requirements of a speech appliance are discussed. The importance of proper speech training following the insertion of a speech appliance cannot be underestimated. The prosthodontist should have the cooperation of a competent speech pathologist when cleft palate patients are treated.

S. G. Applegate and B. S. Savara report the prosthetic treatment of a patient with a congenital ectodermal dysplasia. They discuss the etiology of the deformity as well as the problems of making the prosthetic restorations. The service of prosthetics to handicapped people requires a thorough understanding of the biologic factors and a considerable ingenuity in the treatment itself.

—Carl O. Boucher

THE DENTURE PERIPHERY

G. E. TILTON, D.D.S.

Wichita, Kansas

IN CONSIDERATION of this subject, I think it is important first to make it clear that I do not come with the findings of a research worker. Instead, I wish to discuss this matter as the result of my experiences and observations as a general practitioner in a country practice.

I selected this subject for two reasons. The first and most important is that it has been that part of my denture technique which has given me the most trouble — trouble in time-consuming adjustments, in make-overs, and in dissatisfied patients.

In this field, our research workers and educators have developed a principle or plan that all the tissues of the mouth which are at all tolerable should be covered by the denture base, thereby giving to the denture the maximum of efficiency, stability, and longevity. This principle seemed logical and practical to me at first. Now I firmly believe in it. We usually experience greater difficulty in fitting an abnormally small mouth than one of normal size so that the denture is both comfortable and servicable. Obviously then, the greater the area covered, the more satisfactory are the results.

Accordingly, I embarked upon a program of peripheral extension—an extension into the wide open spaces, namely, the buccal space or vestibule, and the sublingual space. Almost immediately I found myself embroiled in another program of which I had not planned. A program of whittling. I whittled, whittled, and whittled until finally I became the champion whittler of my state.

Some time ago I received a letter from a dentist in a distant city, asking my advice about this subject. He stated that he had journeyed to a far country, and taken a certain training course in full denture construction. As a result he had improved his service very materially, but he was still having to adjust the lower denture three or four times before it was comfortable to the patient. I answered his letter by asking him how he was so successful, also saying I had a number of cases that I had adjusted all through the Depression.

Second, I selected this subject because of its importance. Many times we have heard it said that the most important step in denture technique was the step we were working on at that particular time, meaning of course that each step was of equal importance.

Read before the Chicago Dental Society, February, 1937, and the Full Denture Section of the American Dental Association at Atlantic City, July, 1937.

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In the main I agree with this teaching. No step in denture construction should be stopped short of perfection. Yet, many dentures are worn which have imperfections built into them, provided they have peripheral seal sufficient to hold them in place.

If the denture could speak it would probably say: "Though I speak with the tongues of men and of angels, and have not peripheral seal, I am become as the clicks in conversation, or as a tinkling cymbal.

"And though I have the gift of esthetics, and have been developed by all mysteries in all techniques, and though I have teeth so that I could remove mountains, and have not peripheral seal, I am nothing.

"And though I am in perfect balance in all of my occlusal positions, and though the mind of my wearer has been satisfied by the most expert psychologist, and have not peripheral seal, I shall surely fall into my wearer's soup bowl, and it profiteth me nothing.

"And now abideth centric position, eccentric position, denture space, esthetic values, peripheral seal; but the greatest of these is peripheral seal."

I deem it profitable to discuss briefly some of the reasons why I attained the unenviable position as champion whittler.

The first reason, and probably the most important, lies within me. All my life I have been a hero-worshipper—so much so that many times I have missed the most important thing which makes for success in any endeavor, that of individual initiative, or the power to think a problem through. I have followed instruction and technique by rote.

Hero worship of teachers and distinguished men in our profession is all right to a certain degree, but I have had too many heroes who are at variance upon altogether too many subjects. I have allowed this to keep me constantly changing from one technique to another. It reminds me of my golf game. I have played for eighteen years and I have as yet to play a round without trying something new. Needless to say, I still shoot close to a 100.

Some time ago, a noted gentleman talked before the Chamber of Commerce of my town upon the subject, "The Pain of Thinking." I felt his blows, one after another. The pain of thinking—isn't it a tragedy that it takes one so long to learn a few simple truths?

I often ask myself these questions: Is the responsibility all mine? Has the subject matter always been presented in a comprehensive manner? Has there not been a great deal of vague material introduced in the technique? Have I been wrong when I reasoned that the clinician was giving me his technique, believing, if not hoping, that I could not comprehend? The gentleman to whom I referred a moment ago told this story which will illustrate my point.

One evening at a banquet his father was seated between two distinguished guests who were not acquainted. One was a noted educator, the other was an eminent divine. Feeling that it was his responsibility to start the conversation, he turned to the educator, and asked, "What is your approach to youth?" The educator displayed much learning in explaining how he took a thought from his mature and fertile mind and finally reduced it to a point where the incipient

youth could begin to grasp it, thereby gradually bridging the chasm between youth and maturity. After he had finished the father turned to the Reverend Sam Jones and asked: "And what is your approach to youth?" He received this prompt reply: "I put the fodder on the ground where both the giraffe and the jackass can get at it."

Please do not think I am speaking disparagingly or discounting in any way the work of our clinicians or our teachers for in the language of Popeye, "I yam what I yam" because of the work and sacrifice of these men. However, I *do* believe that more fodder should be thrown on the ground so that a jackass like myself could get at it.

What is meant by peripheral seal? Where does it begin? Where does it end, and how is it accomplished? What is meant by muscle trimming? Where does it begin and where does it end?

Muscle trimming has been taught and practiced for a good many years. However, after quite a thorough search of current literature one may still ask, "Where does muscle trimming begin and where does it end?"

In an approach to this subject I should like to make this statement. We should depend more upon our knowledge of the movement of the tisues in function, more upon the use of a jackknife, and less upon the manipulation of materials. In my opinion, muscle trimming begins approximately 2 mm. upon movable tissue. I believe that this is approximately the amount of movable tissue that will tolerate being held firmly in place without injury or change.

I believe that muscle trimming ends at a point where the border tissues rest firmly, but lightly, against the denture periphery when those border tissues are in extreme function.

Border tissue folds itself around the denture periphery with a different degree of tension for each position of the mandible. I believe it is this fact that is responsible for the complications which have arisen in this part of our work, and for the many techniques that have been devised.

When are border tissues in extreme function? I would say that it is not necessarily when the jaws are closed by the stresses applied in the process of mastication, with the exception of the distobuccal corner of the lower denture. The masseter and temporal muscles which are inserted adjacent to this region are very definite trimmers. All other peripheral tissues may be in extreme function at some time during the process of mastication. If so, there is no way by which this functional position may be recorded; therefore, if a closed-mouth muscle-trimming technique is used, it still must be an arbitrary one, except in the very limited area to which I just referred.

This same line of reasoning may be applied to other functions that are being used to muscle trim. Sucking seems to be a favorite movement to form the periphery. This is not a normal function in the adult patient. Of course, the amount of trimming done would depend upon the force applied. This would vary greatly as some patients make much better suckers than others; therefore, this movement cannot be depended upon.

Forceful movements of the cheeks and lips by the patient are not normal functions and cannot be expected to produce the best result. The same may be said of arbitrary movements of the cheeks and lips made by the operator. The degree of force cannot be determined, so constant results cannot be expected. If these things are true, then it would seem that a norm should be worked out and established by which the general practitioner may be guided.

What are some of the normal jaw movements of an individual in action that develop the maximum tissue stress around the border of a denture?

Yawning is a favorite pastime of middle-aged people, and it is they who make up the largest per cent of the denture-wearing public. Other examples are: yelling at a football game, shouting at the head of the family, singing the doxology, crying because someone has abdicated, laughing over election returns, biting through a frankfurter sandwich, or lecturing from a soap box. If these are normal functions, then muscle trimming as it is generally practiced is wrong.

Obviously, it is impossible for a patient to register all these emotions while an impression is being taken. It is necessary then to select a function or position that will muscle trim to accommodate the foregoing normal functions, as well as the function in mastication. I believe that the wide-open mouth is the correct function or position.

Now that the beginning and ending of the peripheral border has been established (at least for the duration of this paper), let us consider the selection of a suitable material. It should be one that lends itself easily to manipulation, and one in which the value is always constant. Plaster of Paris has long been used for this purpose. For plaster to be invariable under given conditions, it would have to be introduced in just the amount needed to fill the space and have a known fluidity, either of which is impossible. If the material is too soft, the tissues will be placed either on too light a tension or on none at all. On the other hand, if the material is too thick, it will cause the tissues to be overdistended. So, in my judgment, plaster is unsuitable.

Modeling compound presents similar difficulties. In the use of this material, it is necessary for the operator to have an unyielding impression base at the temperature at which the compound is moldable. (Of course this would necessitate the construction of either a vulcanite or metal base.) It is also necessary that the compound be at the exact temperature the operator has decided upon in order to produce the required and constant result. This is practically impossible because of the variables with which one must contend, such as room temperature and the lapse of time between the water bath and the actual muscle trimming. In my estimation, modeling compound is not an ideal material for this purpose. A material that will record in detail, and under the proper amount of tension, the extreme functional position of border tissue is one that is moldable at mouth temperature. A material which meets these requirements and at the same time has all the desirable qualities from the standpoint of manipulation has not as yet been developed. I am using Everett's Extra-Soft Wax. The results are quite satisfactory insofar as placing the proper amount of tension upon tissues is concerned; however, because the material is fragile, it is hard to handle.

FORMING THE PERIPHERY OF THE UPPER IMPRESSION

First, I shall consider the muscle trimming of the upper impression. The first step is to take hold of the lip or cheek in a manner that will cause the tissues to be distended until their highest attachment to the underlying bone and immovable mucous membrane will be clearly shown (Fig. 1). In some areas it will be possible to stretch these tissues to a definite right angle with their attachments. In other areas this will not be possible, but in no area does one have difficulty in definitely outlining the extreme height of these attachments.

Fig. 1.

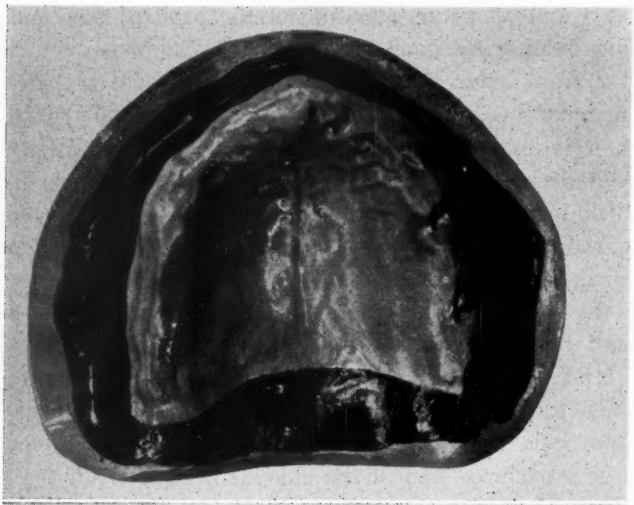

Fig. 2.

Fig. 1.—A cast of the maxillary area. The light area is immovable tissue; the dark area is movable tissue.

Fig. 2.—The light area is a cross section of a cast; the dark area is a cross section of an impression covering 2 mm. of movable tissue.

For years I have placed these tissues under extreme tension, prior to the insertion of a hypodermic needle. It never occurred to me, until recently, that I could use to an advantage in denture work the knowledge of how these tissues move. With this picture of the peripheral anatomy in mind we next cut back the impression base. The base is cut back until we feel sure that we are within 2 mm. of the highest point of tissue attachment (Figs. 2-4). Using an indelible

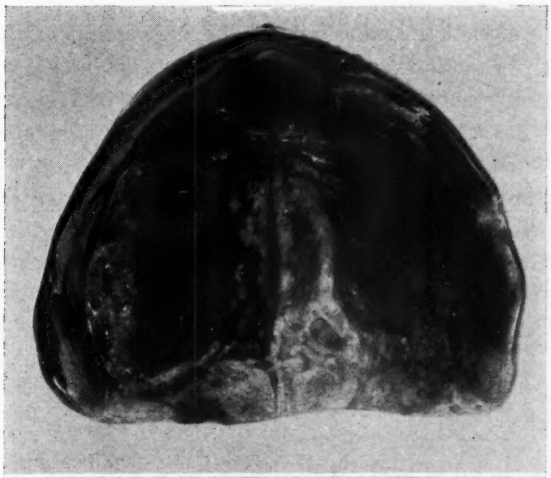

Fig. 3.

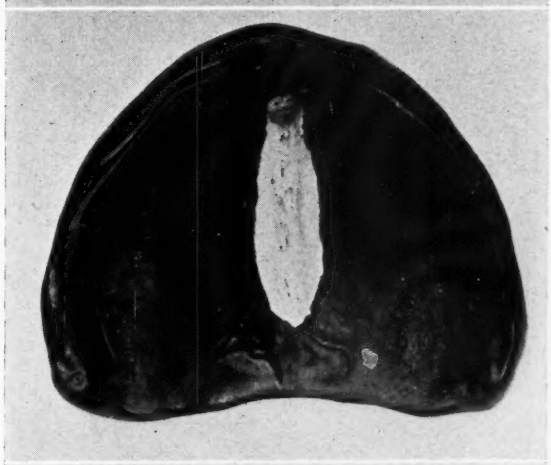

Fig. 4.

Fig. 5.

Fig. 3.—The initial modeling compound impression.

Fig. 4.—The initial impression prepared for a second insertion. The light area is a deep groove.

Fig. 5.—The impression after the second insertion. The light marks are indelible pencil marks to be transferred to tissues of the mouth to locate the post dam line.

pencil a mark is made along the tissue side of the impression at the point where it has been cut back. The marking is also continued to include the post dam area. It is necessary, of course, to post dam within the pterygomaxillary notch. If one examines the impression with an magnifying glass he will find that in the majority of cases the notch will manifest itself in a slight elevation. The elevation can then be marked on either side. The two lines are joined together, thus completing the post dam line over the area to be determined by the operator. Make sure that the post dam is laid upon compressible tissue. (See Figs. 5 and 6.)

The peripheral tissues are sponged free of saliva, the base placed and held firmly for a moment, then removed.

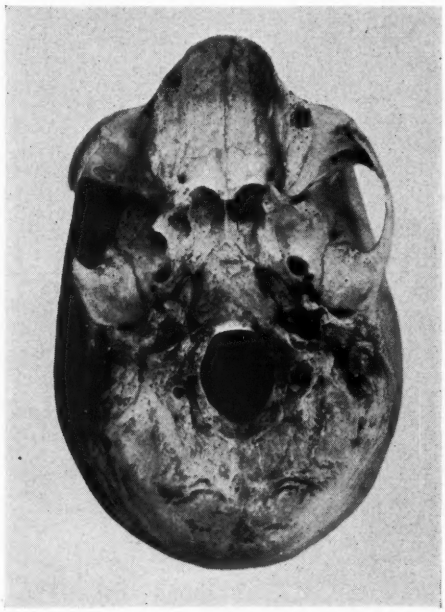

Fig. 6.—A skull showing the important landmarks.

It will be found now that the marking on the base has been transferred to the tissues of the mouth. This will indicate very definitely whether or not the base has been cut back enough. Although the operator may believe that he has trimmed it enough, he will usually find that it still needs to be cut back farther. The technique is repeated until the impression base is of the desired length, labially, buccally, and along the posterior border (Figs. 7 and 8).

The margin of the base is now trimmed for proper thickness. This is an arbitrary trimming for each individual case. It is done according to the judgment of the operator, as the spaces to be fit vary greatly with different individuals.

The labial portion in the majority of cases should be made quite thin. Finishing a denture with the labial border too thick is a mistake that is quite often made. This will destroy proper facial contour and especially the so-called Cupid's bow in the median line. Having finished with the arbitrary trimming of the base, we are now ready to add the peripheral border. However, before describing this step, I wish to discuss briefly the impression base.

THE IMPRESSION BASE

The impression base without the peripheral seal that is to be added, and without being post dammed, will stay in place and can only be easily displaced by exerting force upon the buccal border of one side (Fig. 7). If force is applied from the center and at right angles to the base, it will resist a tremendous pull. This, to me, means that the adaptation is as perfect as it is possible to make it. When a base meets these tests, surely there can be no overcompression or overdisplacement of tissue at any point which would result in atrophy beneath the base. Should the base not meet these requirements or tests, it is imperfect and should be made over.

Fig. 7.

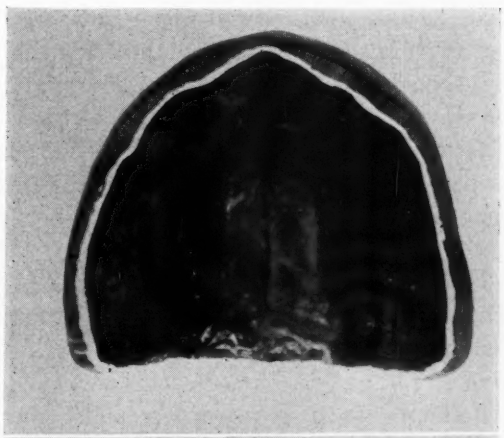

Fig. 8.

Fig. 7.—The height of labial and buccal margins have been made; the post dam line has been determined, and the entire length of these margins checked by the use of an indelible pencil.

Fig. 8.—The impression base has been freely relieved over nonyielding tissue at the median line.

It was, indeed, a source of much satisfaction to me to realize that I could check my impression at this stage. It was satisfying to know the adhesion or so-called suction was a true one due to correct adaptation and not (as many times had been the case) due to an overextension and an overdisplacement of

border tissues. These results are in no way spectacular, but are perfectly logical and natural. The same result may be obtained against a ground-glass slab.

I have been asked the question "Why go further?" In answer to this question, I will say that many of my cases would have proved more satisfactory had I stopped at this stage instead of attempting to muscle trim a modeling compound base, and completing it with a plaster wash, thus finishing the impression not knowing what I had, except that the impression stayed in place.

The impression base, of course, needs the addition of a peripheral seal. It needs it to stabilize and sustain the denture while lateral strains are being applied during mastication and while the explosive functions of border tissues (referred to earlier) are taking place.

I wish to emphasize several points that I believe to be facts: that the making of the impression base and the addition of the periphery are separate and distinct operations; that they should not blend one into the other; that they should not be finished at the same time; and that the impression base should be entirely completed before addition of the periphery is begun. If all else that I have said and shall say in this paper be forgotten, I deem this of sufficient importance to justify my taking your time.

FORMING THE PERIPHERAL BORDER

A roll of carding wax is placed along the post dam line and sealed in place (Fig. 9). The buccal and labial margins are built up with the liquid wax which is applied with a brush. A known excess of wax is applied throughout the entire border. The impression is placed in the mouth and allowed to remain until it has reached mouth temperature. It is then held firmly in place and the patient is instructed to open the mouth wide. The impression is held until the wax has had time to flow. It is then chilled and removed. The excess wax is cut away and the impression is again placed into the mouth. This process is repeated until there is no more wax to be removed. Additional wax may be added at any time.

After the first insertion, it will often be found that the wax has been entirely removed from along the margin of the tissue side of the impression base. This may be due to an excess amount of material or to an overextended base. If, upon the second removal of the impression base, the dragging of the wax from the margin of the base has again taken place, then the base is still too long. That area which has been uncovered must be cut away, a small amount of wax added, and the impression completed upon the next insertion. This produces a finished impression under which there is no intolerable tissue displacement and one which, in my opinion, will give the longest possible service (Figs. 10-12).

FORMING THE LOWER PERIPHERAL BORDER

We are now attacking a much-discussed problem. The lower denture has been a topic for more massive mythology than any other dental subject of our times. We are led to believe that it may be necessary for us to go into solitary confinement, and there wrestle with the known and the unknown, with natural

Fig. 9.

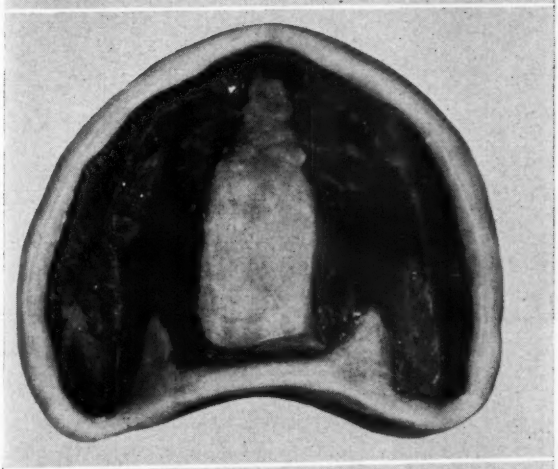

Fig. 10.

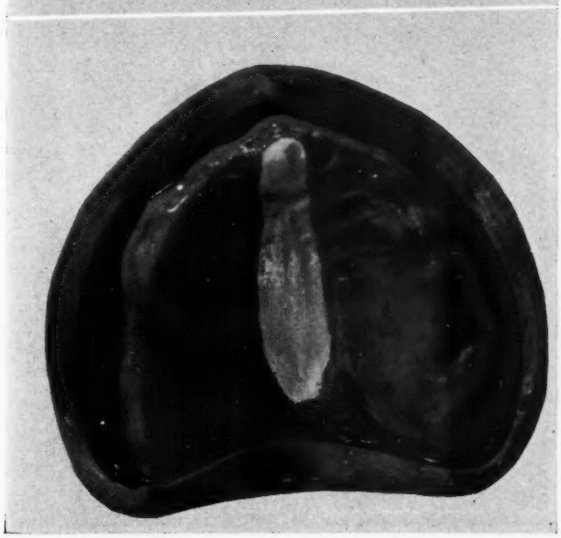

Fig. 11.

Fig. 9.—The impression base was Everett's Extra-Soft Wax applied in the median area. A roll of black carding wax is sealed over the post dam area. This material, when placed under heavy pressure, will result in an automatic relief over nonyielding tissue and a proper post dam.

Fig. 10.—The finished impression. Peripheral margins are recorded in a material which is moldable at mouth temperature, and with mouth opened wide.

Fig. 11.—The final cast.

and unnatural phenomena, and with all hidden mysteries. After a time we will finally emerge victorious, endowed with certain superhuman rights which only a very few people can ever hope to acquire. Or we may enter someone's sanctum. There we will strive earnestly to master in detail the complicated technique of a mastermind. We may finally return home with sufficient cleverness to be able to properly build a lower denture.

I wish to assure you that the process is not as complicated as that. In fact, it is quite a simple one. The lower denture, with the exception of a few small areas (and in some mouths only a few small spots) rests upon movable tissue. That tissue cannot be displaced except with a very slight tension, and that tension must be uniform throughout the whole area. Or, in other words, there must be a balanced tissue tension. If this concept is true, then the general practitioner need have no fear, nor feel that he is lost and must proceed upon blind faith. Instead, he may build into his technique factors which produce these results.

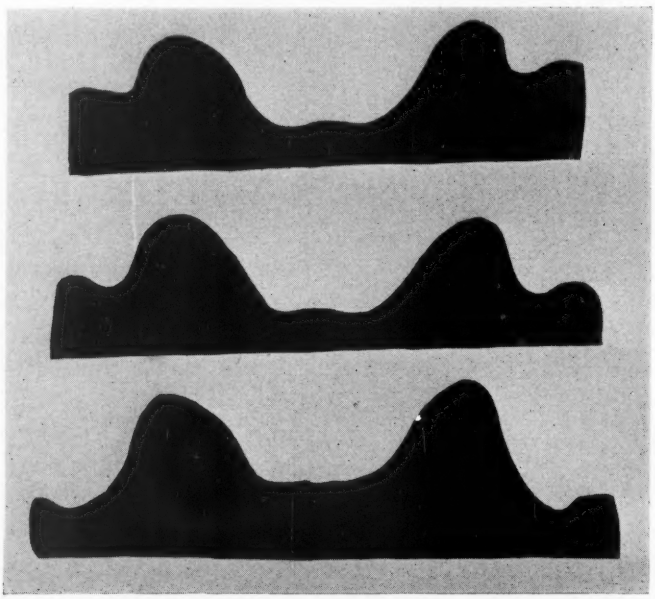

Fig. 12.—Cross sections of casts made from impressions of the same mouth. The impression bases for the center and bottom sections were the same height. Top, From an initial impression. Center, From an impression muscle trimmed in wax. Bottom, From an impression muscle trimmed in soft plaster.

From the south and from the north, from the east and from the west, come reports of great extensions out into the buccal area or vestibule, and down into the sublingual space. To be sure, one may go out into these areas but, I repeat, one may not go out under pressure.

Before discussing the muscle trimming of the lower impression it will be necessary to describe the base.

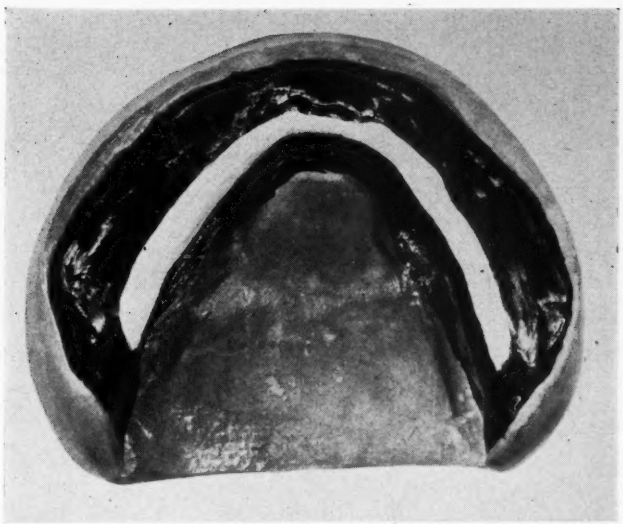

Fig. 13.

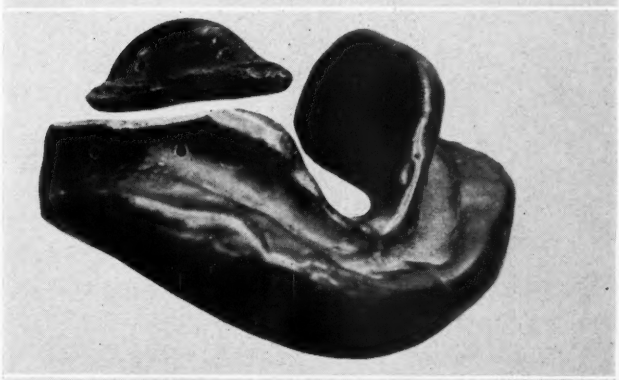

Fig. 14.

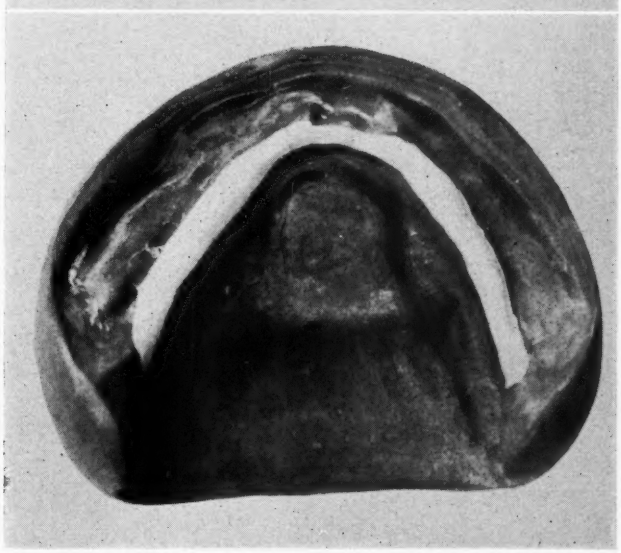

Fig. 15.

Fig. 13.—A cast of the mandibular area. The light area is immovable tissue; the dark area is movable tissue.

Fig. 14.—The initial lower modeling compound impression.

Fig. 15.—The cast made from the initial compound impression. The light area indicates the extent of the fixed tissue.

THE LOWER IMPRESSION BASE

The base is made over a cast which has been made from the initial impression (Figs. 13-15). By closely adapting baseplate material to it, the buccal and lingual sections are made at least 3 mm. thick (Fig. 16). The ridge area is now reinforced with a low fusing metal. The forefinger wrapped with a napkin and used as a matrix is held against the lingual flange. The molten metal, a small quantity at a time, is now poured from a small spoon instrument against the matrix. This consumes only a few minutes, but it makes a firm and unyielding base that can be handled without fear of distortion. In some cases, due to the irregularity of the cast, it will be found impossible to remove a closely adapted baseplate. In those cases we make sure that all of the primary stress-bearing areas or spots are closely adapted. Other areas are left loose enough that the base may be removed from the cast. The closely adapted sections over the primary stress-bearing areas are to act as stops while the base is being corrected and while the muscle trimming is being done.

The base is now lined with a zinc oxide and eugenol impression paste and placed in the mouth. It is held firmly in place until the impression material has set. This produces a very accurate impression base.

DETERMINING THE LENGTH OF THE BASE

The addition of the peripheral margin of the lower impression is accomplished in a somewhat different way than the upper impression. The impression base for descriptive purposes is divided into labial, buccal, distobuccal angle and lingual sections. The amount of tissue covered in the buccal and lingual sections is dependent entirely upon the case being treated.

In the buccal area, the base is cut back inside of the external oblique line (Fig. 17).

The length of the lingual border depends entirely upon the functional range of the tongue, and can only be approximately determined. But the patient should be able to use a little more than one-half of the tongue movement of which he is capable. In other words, if he is able to protrude his tongue 1 inch beyond the vermilion border of the lip, then he should be allowed a minimum of ½ inch protrusion.

The labial area including the buccal frenula, and the distobuccal angle, including the tissues adjacent to the attachments of the masseter and temporal muscles, are treated in much the same manner as for the upper impression. The base is cut back until only approximately 2 mm. of movable tissue are tied down. (See Fig. 17.)

MUSCLE TRIMMING OF THE LOWER IMPRESSION

We now relieve the impression base over the nonstress-bearing areas and the areas over which there are sharp spines of bone, and line it with wax, plaster of Paris, or a similar material. If the impression base is made of vulcanite or of metal, we may line it with modeling compound. If it is then placed into the mouth under pressure and muscle trimmed, we will finish with a denture which has a spectacular fit, but one in which the border tissues surely have been overdisplaced.

Fig. 16.

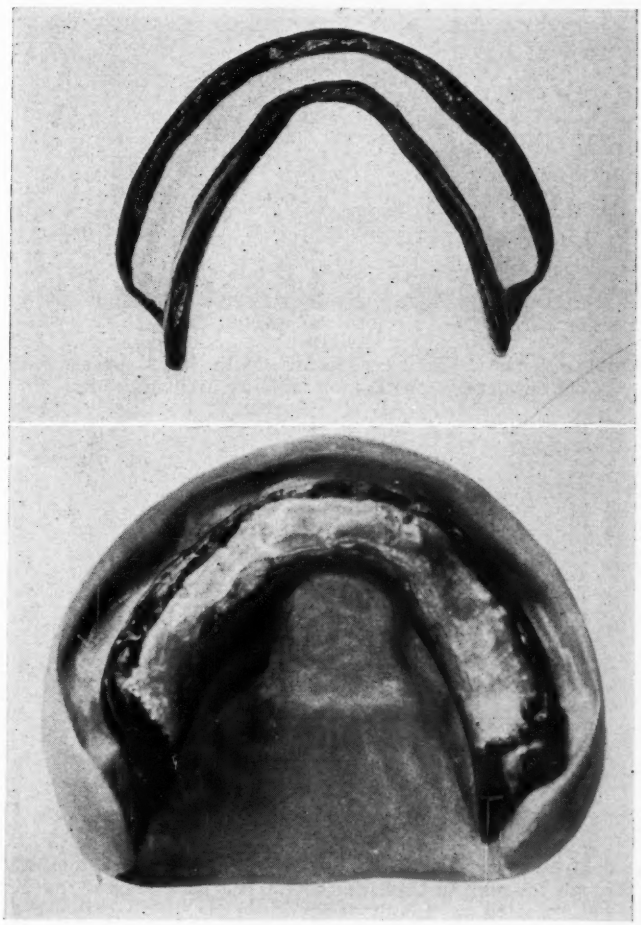

Fig. 17.

Fig. 16.—The impression base constructed from a baseplate material. The light area covers the immovable area together with the amount of movable tissue firmly held in place.

Fig. 17.—The reinforced impression base as it appears in the mouth, before the soft wax has been added.

The length of time this spectacular fit will persist is problematic, depending entirely, I believe, upon the severity of the overdistension of the underlying tissues. It may last a month, a year, or even longer, but eventually there will be tissue change or there will be chafing of tissue beneath the buccal and lingual flanges. This will call for an adjustment, with the result that eventually this fine fit will be lost.

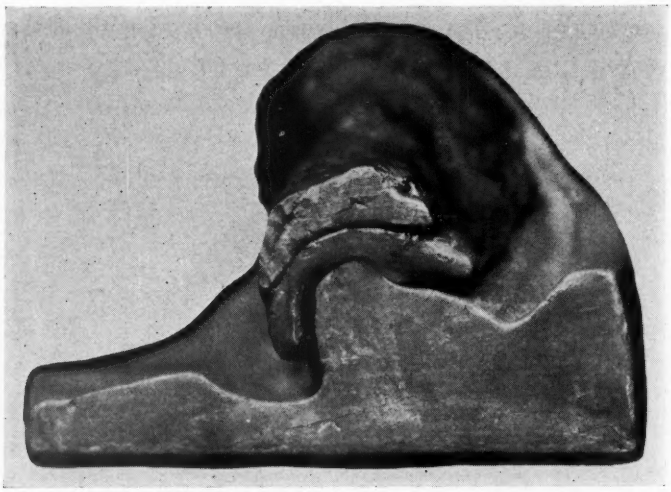

Fig. 18.—Cross section of the reinforced impression base as it appears in the mouth. The dark area shows the extent of the arbitrary relief.

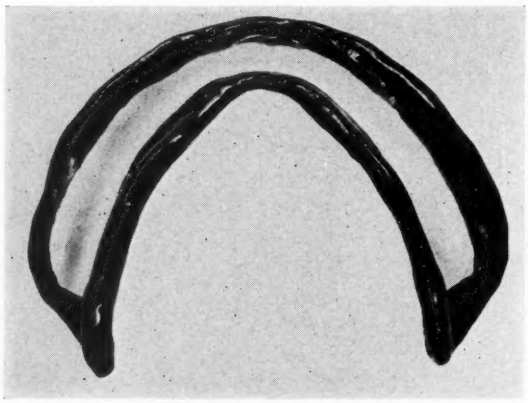

Fig. 19.—The final impression. The light area covers tissues held firmly in place. The baseplate shows through the wax in this area only. The dark area is the peripheral margin recorded in soft wax, molded at mouth temperature by holding the mouth wide open.

I prefer to treat the impression base as follows: All areas which are capable of carrying the primary load are located on the impression base. (See Fig. 16.) All areas covering abnormal movable tissue and all areas covering sharp spines are freely relieved. Special attention is given to the relief of the lingual flange high up to include all of the mylohyoid ridge and genial tubercle (Fig. 18).

In this area, it is the movable tissues with their attachments which assist in depressing the mandible; hence they are under great tension when the mouth is wide open. Therefore, the impression base over these tissues must be freely relieved.

The base is now lined with wax, placed into the mouth and held under firm pressure until the material has reached mouth temperature, and has had ample time to flow. The mouth is held wide open and the tongue protruded. The impression is chilled and removed, the excess is cut away and the trimming repeated until no excess appears (Fig. 19).

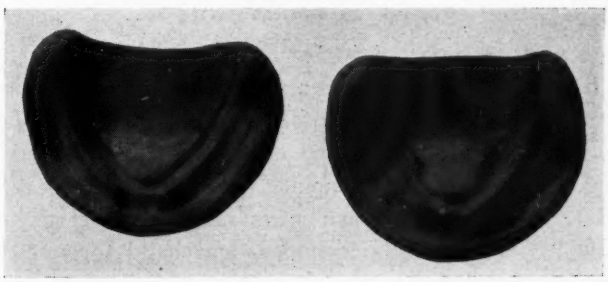

Fig. 20.—Right, The initial cast; note the external oblique line. Left, The final cast.

Fig. 21.—Cross section of the lower cast of the same mouth through the molar region. Top, From an impression made in soft plaster with the tissues at rest. Center, From an initial impression made in modeling compound. Bottom, The final cast.

The base should show through the wax only in the primary stress-bearing areas. If other areas show through, these areas are still fitting too closely and must be further relieved.

A denture made over a cast from an impression of this type will be one covering a broad area that will have just enough adhesion to hold it in place (Figs. 20 and 21). In fact, it will not require as much adhesion to hold it in place. It will be one with which the patient can masticate, sing, speak, shout, yawn and laugh. This is as much and more than I can do with my natural teeth, for I have not as yet learned to sing.

It will be one under which there will be a minimum of tissue change, for no soft tisue has been compressed beyond a state of physiologic activity. If these things are true, then we may expect a long and comfortable service.

SUMMARY

In closing, I wish to make an appeal for standardization in impression techniques for the benefit of the general practitioner. It has been said many times that this cannot be done; that it is impossible for men to agree upon a technique; that if it were, it would stifle individual effort, thereby delaying progress. We are told that success depends upon ability, care, and skill. We are also told that we should be able to apply such parts of the several techniques that are best suited to us, and in this way formulate and build for ourselves a practical and workable technique. I do not believe that these arguments are wholly sound.

The anatomy with which we must deal is always the same. At least all mouths will respond to the same general treatment. The materials for this use are available to all of us. There is but little difference in the dexterity of our hands. Certainly we are intelligent enough to apply a standard technique.

One needs but to visit a commercial laboratory and see the variety of techniques being applied, and the bewilderment manifested in many of them, to realize the very great need for a standardized technique. I believe that, when the salient principles and requirements are understood, a technique can be standardized just as well as a material can be standardized.

I hope to see, some day not far distant, a report brought from some representative group which will give us, the dentists in general practice, an authoritative standard technique. I am sure that this would result in a mighty move forward in this branch of our work, and that much benefit and comfort would accrue to those whom we serve.

1006 Union National Bank Bldg.
Wichita 2, Kansas

A REVIEW OF SOME OF THE PROBLEMS ASSOCIATED WITH CENTRIC RELATION

R. H. KINGERY, D.D.S.

School of Dentistry, University of Michigan, Ann Arbor, Mich.

THE NATURE of the problems associated with the maxillomandibular relationship of centric relation is such that it proves a worthy subject for constant review. This subject has been considered again and again. Because of this repetition, may it be clearly understood that my remarks are made with full consciousness that I merely quote the thoughts of others. Any attempt to name the many who have contributed to our concepts of centric relation would be futile. May I pay fitting recognition to all of them and their contributions by stating that my objective is to repeat, I hope in a practical manner, the thoughts they have given.

Assuming our approach is that of treating edentulous patients, let us select four problems associated with centric relation, which are always present. I refer to the problems of: (1) what is required, (2) errors, (3) how errors manifest themselves, and (4) recording centric relation.

PROBLEM OF REQUIREMENTS

While undoubtedly such a division sounds very elementary, one must acknowledge that a thorough understanding of the requirements of that which we seek to accomplish is a prerequisite to the successful conclusion of our endeavors. Before considering requirements, several fundamental points should be mentioned:

1. The position of the horizontal relationship of the mandible to the maxilla, known as centric relation, is a positional relationship inherent to each individual. We do not establish centric relation, we do not "take" centric relation, we *record* centric relation (Fig. 1).

2. The familiar and generally accepted definition of the correct anteroposterior relation of the mandible to the maxilla, or centric relation, is: the most retruded unstrained position of the heads of the condyles in the glenoid fossae, at any given degree of jaw separation, from which lateral jaw movements can be made.

To accept this statement is to agree that the term "true centric" is a misnomer, one which is confusing and which should be eliminated. If centric relation is a specific jaw position, all other positions must be regarded as eccentric positions. To accept any record of a position of the mandible other than centric position, spoken of as "functional centric," "acquired centric," "habitual centric," etc., is to record an eccentric position. Our awareness of these so-called "easy" positions

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should serve to stimulate our care in the proper articulation of the teeth, but these positions should not be confused with centric relation.

3. We record centric relation; we establish centric occlusion to coincide with this position. While this is a simple statement, it must be constantly kept in mind to avoid confusion. To occlude means to close, or bring two opposing surfaces into contact. We occlude occlusion rims, tracing devices, and teeth.

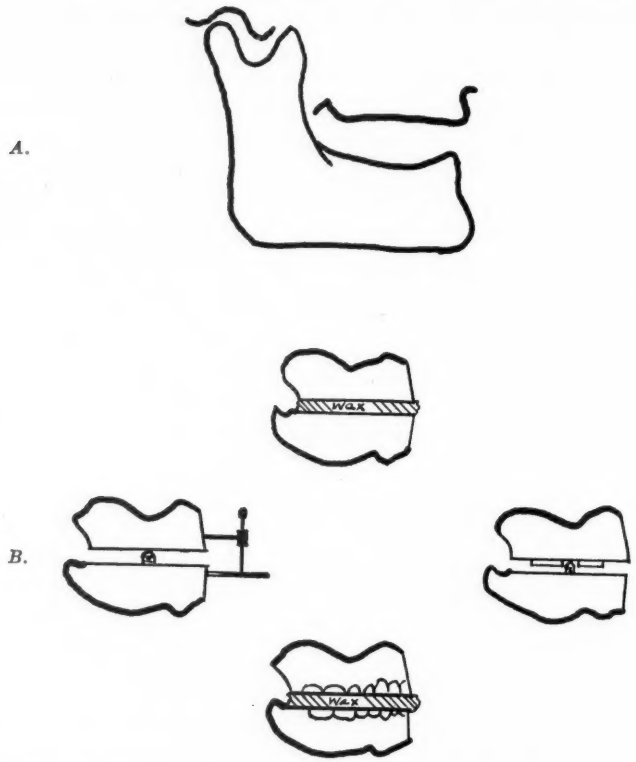

Fig. 1.—Centric relation.

A, A positional relationship inherent to each individual at any given degree of jaw separation.

B, Examples of methods used in recording centric relation.

Hence, the occluding contacts of any of these become our point of reference in judging whether the centric occlusion we have established coincides with the centric relation of the jaw. Centric relation might be regarded as a template or pattern which we must fit with the centric occlusion we establish. I would like to stress the point that, regardless of techniques or gadgets, the final verification of whether centric occlusion coincides with centric relation depends upon the integrity, knowledge, and visual observation of each individual operator.

Let us consider the requirements we seek to fullfill in recording centric relation. These requirements are so interrelated that failure to complete both correctly results in annoying difficulties, or complete failure of the final restorations. These two requirements are: (1) Recording the correct anteroposterior or horizontal relationship of the mandible to the maxilla in a position of centric

relation. (2) Equalization of contact on the denture-supporting areas, which I will call equalization of vertical contact. (Fig. 2.)

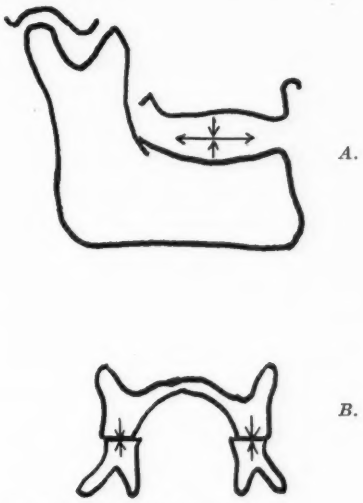

Fig. 2.—Requirements of a centric relation record.

A, Correct horizontal relation of the mandible to the maxilla.

B, Equilibration of contact on the denture-supporting areas (equilibration of vertical contact).

It is rather sad that our generally accepted definition of centric relation made no mention of equalized vertical contact. I cannot help but feel that many men record the correct horizontal relationship of the mandible to the maxilla, but fail to consider the importance of equalization of contact. Such a failure to complete our requirements undoubtedly accounts for some of the many difficulties experienced with dentures.

PROBLEM OF ERRORS

To prevent an error, one must be able to recognize it, as well as understand what may be its cause. In order to discover if an error is present, we must have points of reference to use as checks. For these, we use occluding surfaces such as occlusion rims, tracing devices, or finally the teeth on the restorations. We say there is an error when the centric occlusion of these occluding devices does not coincide with the centric relation of the patient. The error may be gross or very minute. The error may be either an incorrect horizontal relation of the mandible to the maxilla, or it may be an incorrect equalization of vertical contact (Fig. 3).

At this point it seems to me that an opportunity presents itself to clarify our general understanding of this problem of errors. I have said that in complete denture treatment we record centric relation; we establish centric occlusion. What we establish must coincide with a relation inherent in each individual patient. Hence, we do not make errors in centric relation; neither can we loosely say "the centric relation is off." What actually happens is we either make an error in the *registration of centric relation,* that is, our record is incorrect, or something has happened which causes the centric occlusion we have established

to fail to coincide with the record of centric relation. For convenience, may I speak of these as positional errors and technical errors.

Let us consider a few of the possible causes of these two classes of errors.

Positional errors may be caused by: (1) Failure of the operator in his registration of the correct horizontal relationship. (2) Failure of the operator to record equalized vertical contact. (3) Application of excessive closure pressure by the patient at time of recording. (4) Changes in the supporting area. May we be forever conscious that the position of centric relation varies with different degrees of jaw separation. It is well to remember that the record we use to establish centric occlusion remains correct only as long as the supporting areas remain constant. If a record was made on each patient of the amount of jaw separation present (vertical dimension) when centric relation was recorded, it would prove valuable information if it became necessary to correct the bases after changes had occurred. It should be recognized that, in rebasing a denture, if as much thought was given to restoring the original vertical dimension as is given to improving tissue adaptation, our objectives would be accomplished better.

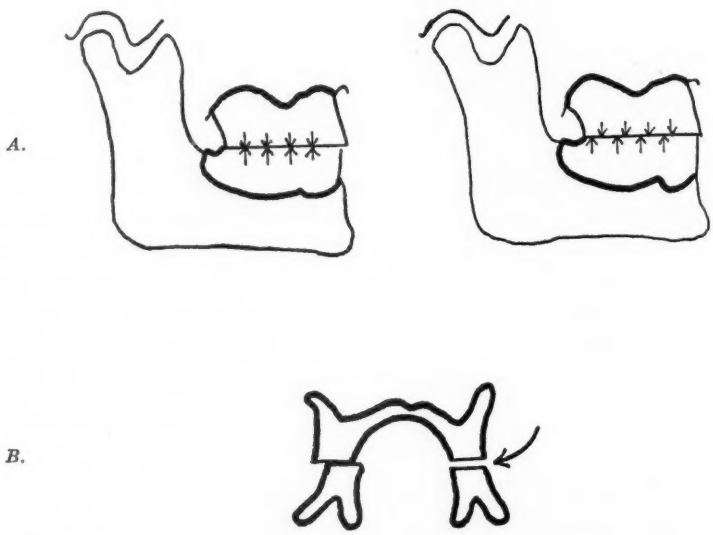

Fig. 3.—Types of errors.

A, Error in horizontal relation. The points of reference which have been established do not coincide with the centric relation of the patient. Left, Correct. Right, Incorrect.

B, Failure in equilibration of vertical contact.

Technical errors may be caused by: (1) Ill-fitting occlusion rims. A record will never be any more accurate than the bases upon which it is made. (2) Indiscriminate opening or closing of the occluding device or articulator. An articulator, in reality, is a jig which maintains a record or records of position. Even if the casts are mounted correctly, the amount which we can arbitrarily vary the vertical distance between the casts is limited. Too frequently the laboratory technician opens or closes the vertical distance of the articulator for convenience in tooth arrangement. This results in the establishment of a centric occlusion which does not coincide with centric relation. (3) The slight shifting

of teeth which occurs between the stage of final arrangement in wax and the transfer to a permanent base material. A movement by a tooth or several teeth, either horizontally or vertically, introduces an error. The common, and I might say excellent, practice of returning the processed dentures on the casts to their original mounting on the articulator provides an opportunity to correct these errors. Many men believe such a procedure corrects all errors. Such a belief is a fallacy. Granted that such a procedure allows for correction of the centric occlusion we have established with the centric relation we have recorded, it is still no proof that the original recording was correct. Once more, may I remind you that the final verification of whether the centric occlusion which has been established coincides with the centric relation of the patient is possible only by careful observation and checking in the mouth.

PROBLEM OF RECOGNIZING THE SYMPTOMS OF ERRORS ASSOCIATED WITH CENTRIC RELATION

One might say, without fear of contradiction, that failure to fulfill the requirements in recording centric relation provides at least a part of the etiology of looseness and irritation in restorations. While such a statement is true, it is of little value because it is not specific. There are many causes for loose dentures, or irritation to the area supporting dentures. There is little doubt that one very common reason for the confusion in denture treatment is the multiple causes of looseness and irritation. Because of this, it is essential that one becomes familiar with the symptoms which result from errors in recording centric relation. To recognize these symptoms is a valuable aid in diagnosing one of the causes of denture difficulties or failure.

May I repeat, there is an error when the centric occlusion we have established does not coincide with the centric relation of the patient, and there is an error when there is unequal vertical contact.

Let us consider some of the symptoms. In discussing this problem our viewpoint must be that of checking dentures.

Some symptoms of *unequalized vertical contact* are:

1. Loss of retention. Retention, as we know, depends to a great extent upon uniform contact between the denture and the supporting tissue. If the contact between the teeth of the opposing dentures is not uniform, the dentures are actually unseated each time the patient closes in centric relation. While loss of retention may be manifested in either or both dentures, I am inclined to feel that we see this particular error manifested in the lower dentures more frequently.
2. Irritation on the crest of the lower ridge in the area of premature contact. This may be a small localized ulcer with unbroken surface, or it may be a generalized area which is usually hyperemic.
3. One tooth or several teeth on one side seem long to the patient or seem to strike first. Many times it is necessary to question the patient regarding unilateral premature contact as they are not aware of the importance of this information as a symptom.
4. The patient may complain of clicking if the teeth are of porcelain.
5. Premature contact anteriorly or posteriorly.

Symptoms of an error in *horizontal relationship* are frequently found in those instances where the centric occlusion which has been established does not coincide with centric relation of the patient. As an aid in the recognition of these particular symptoms, we state that, in the horizonal relation, errors may occur either anterior or posterior to centric relation. Let use consider each type of error:

1. When the centric occlusion established in the arrangement of teeth is anterior to the centric relation of the patient, we have an anterior error (Fig. 4). In the clinical picture, the patient must protrude the mandible to have the teeth contact correctly in centric occlusion. Examples of the cause of this error, as has been stated, are: failure to record the correct horizontal relationship of the mandible to the maxilla, excessive opening of the articulator from the original mounting record, etc. Some of the symptoms of this type of error are: (a) Looseness, especially of the mandibular denture. (b) Denture consciousness. The patient may complain that the teeth do not come together properly. Here again it is well to question the patient. Have him contact the teeth very lightly, then apply pressure. If there is a slight slide into centric occlusion, it is a symptom of this type of error. (c) Irritation under the anterior lingual flange of the mandibular denture is a symptom I wish to stress. May I digress for a moment to state that in most instances the clinical picture of overpressure, or abnormal pressures resulting from faulty occlusion, is redness turning to whitish blisterlike appearance and edema. The clinical picture of overextension is usually an actual break or cut of the tissue in the region of the periphery of the denture. Hence, whenever irritation is evident under the anterior lingual flange of the lower denture, it is well to check for the error of failure of centric occlusion to coincide with the centric relation of the patient.

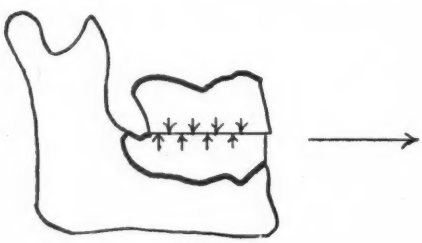

Fig. 4.

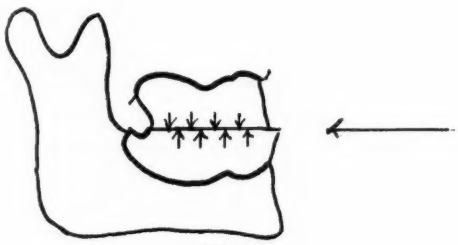

Fig. 5.

Fig. 4.—Anterior error. Centric occlusion (judged by points of reference) which has been established is anterior to centric relation.

Fig. 5.—Posterior error. Centric occlusion (judged by points of reference) which has been established is posterior to centric relation.

2. The second type of horizontal error exists when the centric occlusion which has been established in the arrangement of teeth is posterior to the centric relation of the patient (Fig. 5). In discussing the cause of this error, may I call attention to the fact that it is extremely rare for such an error to occur as a result of a faulty registration. This error may occur as a result of excessive arbitrary closure of the articulator; however, its most common cause is a loss of tissue support under the dentures. Whenever the interarch distance changes from that at which centric relation was recorded (supporting base area changes), this type of error starts to manifest itself.

The symptoms of this type of error are: (a) Looseness, especially in the maxillary denture. The upper denture is driven forward on closure and frequently is dislodged. I cannot help but point out in this connection, in rebasing a denture, it is imperative that we try to restore as closely as possible the original vertical dimension at which the dentures were articulated. (b) Irritation under the anterior labial flange of the mandibular denture. This symptom is noted only occasionally. One cannot leave a discussion of this particular type of error without reminding the readers that the frequency of its occurrence is directly proportional to permanency of ridge support. Patients presenting with poor denture-supporting structures should alert us to the possibility of its occurrence.

These symptoms we have considered may be caused by even slight errors. Naturally the severity of the error would influence the method of correction. Gross errors would necessitate remaking. Errors resulting from mouth changes, if not too extreme, can be corrected by rebasing, if care is taken to restore the dimension at which the original centric relation recording was made. Slight errors can be corrected by recording the correct centric relation position. Wax of uniform consistency may be used between the teeth of the opposing dentures as the recording medium. The dentures are placed in this record, correctly mounted on an articulator, and centric occlusion is corrected by selective grinding.

Undoubtedly, mention should be made of technical procedures in checking our restorations to determine if they are in error. To explain these methods seems unnecessary for description of the use of the check bite for checking occlusion is, I am sure, familiar to all. The only thing about these technical procedures I would like to stress is that every operator should have the *courage* and *integrity* to check and to determine whether or not the centric occlusion he has established coincides with the centric relation of the patient.

PROBLEM OF RECORDING CENTRIC

Perhaps I should have headed this section, "Confusion Caused by the Number of Methods Advocated and Arguments Advanced In Support of Each Method." There are many methods, everything from electric lights flashing on to the individual who tells the patient to just close and "hold it."

For the sake of the young men who are to follow us, is it not possible to present at least a clearer concept of this problem? It is with this objective in mind that I present the following thoughts for your consideration.

I believe it is possible to record centric relation correctly by any one of the many methods. I also just as sincerely believe that it is possible to make an error with any method. Why such contradictory statements? Simply this—any method, regardless of the trick instrumentation employed, is only a means to an end. The correctness of any individual registration is never assured until it is checked and verified by the observation of the operator. Too many operators are prone to accept without question the recordings resulting by this or that method. This attitude, that certain methods cannot fail, results in a lapse of vigilance in checking, which frequently subjects the patient and the operator to the trying difficulties resulting from errors in recording centric relation.

I have said that I believe it possible to correctly record centric relation by any method. I call your attention to the word "possible," because I feel there are certain methods which, if followed carefully, will have a higher percentage in accuracy rating. What is a good method? It is a method that produces a registration which, in the greatest majority of cases, when checked back in the mouth of the individual from which it was made, coincides with the centric relation position of that patient. I could mention six outstanding men around the country who are meticulous workmen, who check and double check each step. Each man of this group uses a different method for recording centric relation. What does this mean? I cannot bring myself to believe that two are right and four are wrong; rather it merely indicates that methods may vary, but final results depend upon the individual operator.

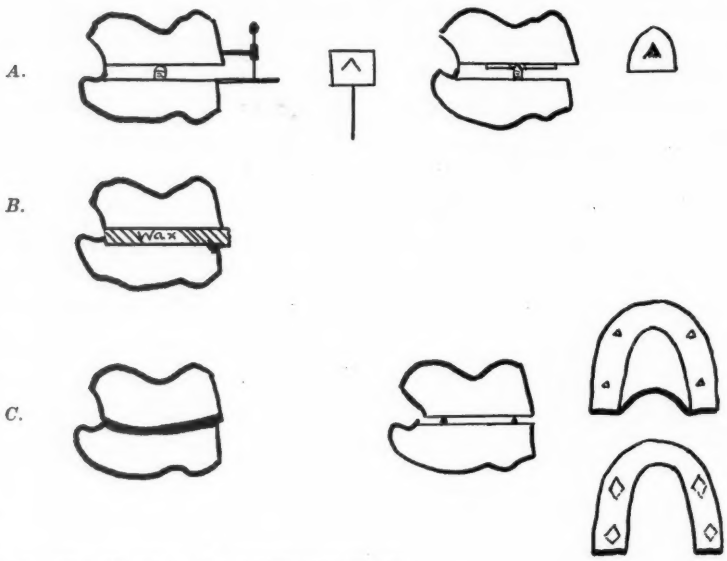

Fig. 6.—Classification of recording methods.

A, Graphic recording. Left, Extraoral procedure. Right, Intraoral procedure.

B, Direct check bite recording.

C, Functional or chewed-in recording. Left, Wax or abrasive occlusion rims. Right, Cutting studs.

In considering the problem of methods, mention should be made of the difficulties presented by some patients—nervousness, fright, tension, habits, illness, age, and so forth. These conditions frequently prove extremely troublesome in recording centric relation. Medication has been suggested for some patients to encourage their relaxation. Resorting to a different method of registration sometimes is helpful. Such patients place an extreme test on our abilities to verify our recording. Not only should multiple checks be made during the actual construction of these dentures, but also through the adjustment phase of treatment.

We would accomplish little to describe the various methods for recording centric relation. The majority of these procedures are an old story to all of

you. Instead, I will group these methods and attempt to review their limitations and possibilities (Fig. 6):

1. Graphic Recording. Methods employing a graph or tracing as guides for a check bite.
   (a) Extraoral tracing procedure.
   (b) Intraoral tracing procedure.
2. Direct check bite recording.
3. Functional recording (chew-in procedure).

GRAPHIC RECORDING METHOD

The basis of the graphic method is the Gothic arch tracing sometimes referred to as the arrow point tracing. This tracing, or tracings, represent the movement of the mandible on one plane. If the mandible describes its entire movement on this plane, the resultant graph will be in the form of a V. When the heads of the condyles are in their most retruded position from which lateral movements can be made, the point of the tracer will rest in the apex of this tracing. In fairness to the Gothic arch tracing, it may be stressed that its only purpose is to establish a visual point of reference. Careless recording of this position is beyond the scope of the tracing. It is essential that a fine sharp pointed tracer be used, for any record made with such guidance is accurate only if recorded with the tracer in the exact apex of the tracing. A faulty or imperfect tracing may be caused by loose occlusion rims, interference in occlusion rims, and occasionally a lack of cooperation by the patient. No tracing should be accepted unless it presents a clean-cut apex. These points regarding the Gothic arch tracing apply to any tracing whether developed intraorally or extraorally.

As has been stated, the arrow point tracing should be looked upon only as an aid in establishing (as the machinist would say) a construction point which refers only to the anteroposterior jaw relation. Not only must a record be made of this anteroposterior jaw relation but, to meet the requirements, this record must be registered with equalized vertical contact.

To accomplish equalized vertical contact with the graphic method, we must use a central point of bearing between the occlusion rims when recording the position. While I do not wish to confuse by a play on words a central bearing point only becomes a central point of bearing when it is placed properly. Too long we have looked upon the central bearing point as assurance for equilibrium of contact regardless of its position. This is a fallacy. If the bearing point is not placed with the point of bearing in the center, then the error of unequalized vertical contact is introduced. The degree of error would be proportional to the amount of pressure applied by the patient in closure and the displaceability of the supporting tissue.

Dr. C. J. Stansbery brought out a method for checking the correctness of the position of the central bearing point. In using Stansbery check bite plates, one rod is passed through the stylus holder on the upper plate, and the other is attached to the tracing table on the lower plate. When placed in the mouth and the bearing point brought into contact with the upper plate, the rods should

be parallel as viewed from any angle. If the rods are not parallel, the bearing point must be moved until parallelism is attained. Undoubtedly adaptation of this method of indicating correct positioning of the central bearing point could be made whenever extraoral tracers are used. This appears to be an excellent method, and I know of no other means of checking bearing-point position with equal accuracy (Fig. 7).

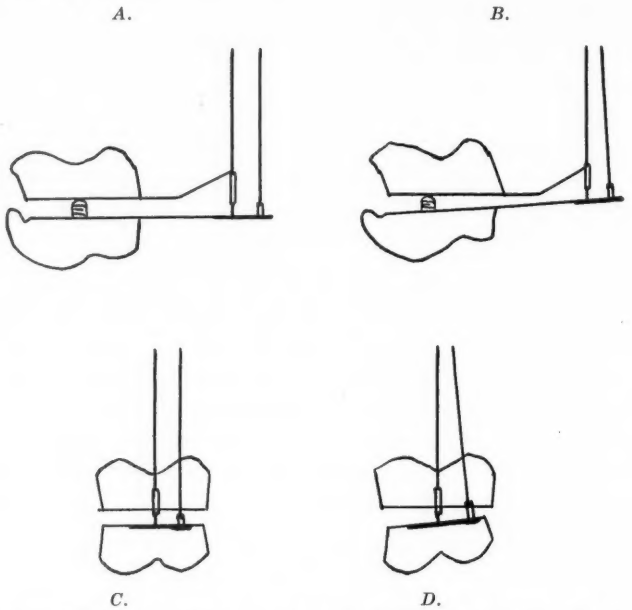

Fig. 7.—Stansbery method. Checking position of central bearing point.
A, Correct. Vertical rods parallel.
B, Incorrect. Vertical rods not parallel (central bearing points must be moved forward).
C, Correct. Vertical rods parallel.
D, Incorerct. Vertical rods not parallel (central bearing point must be moved to right) as seen in this diagram.

Undoubtedly, error in proper placement of the central bearing point could be reduced if more time was spent in a careful attachment of the bearing-point device to the occlusion rims. The bearing-point device should be mounted on the occlusion rims in a horizontal position and parallel to each other. If the device is mounted in this manner, a check on the accuracy of the position of the central bearing point can be made by having the patient close in approximately the position of centric relation and apply reasonable pressure. If the occlusion rims do not remain parallel to each other, the central point of bearing should be moved until such parallelism is attained (Fig. 8).

A central bearing point is a device which aids us in accomplishing a certain end. It will fulfill its objective only as well as it is made to, by the one who uses it. At best, I feel it has certain limitations. In the first place, it allows for no control over the amount of closing pressure applied by the patient. Second, patients presenting extreme protrusion or retrusion of the mandible make proper placement of the central bearing point extremely difficult, if not impossible. Third,

patients presenting large clumsy tongues, extreme resorption of ridges, or extensive amounts of displaceable tissues on the supporting areas prove troublesome when a central bearing point is used.

We have considered in reality two instruments, a tracing device to record a visual position, and a central bearing point to establish equilibration of vertical contact. To complete our story of analysis of the graphic method of recording, we briefly consider the methods of procedure.

Extraoral procedure.—The Gothic arch tracing is developed extraorally, allowing full view at all times. Plaster injected between the occlusion rims and central bearing point is used as a recording medium. Such a method avoids any necessity to lock a patient's jaw in a certain position. It also allows the operator to detect at once any jaw movement, on the part of the patient, from the apex of the arch tracing.

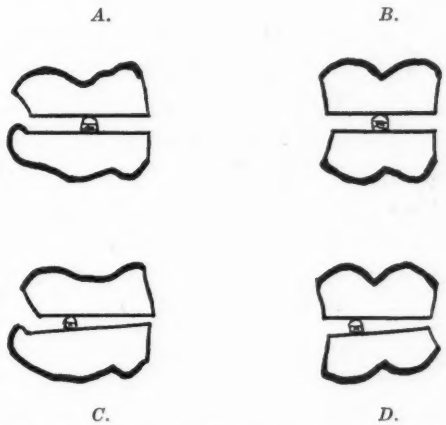

Fig. 8.—Parallelism of the occlusal planes of the occlusion rims aid as a reference in proper placement of the central bearing point.

A, Correct.

B, Correct.

C, Incorrect. Bearing point should be moved forward.

D, Incorrect. Bearing point should be moved to the right.

Intraoral procedure.—The Gothic arch is developed with the central bearing point. The bearing point is locked at the apex of the tracing, and plaster is injected as a recording medium between the occlusion rims.

I cannot help but believe that the abuses of this method are much more deserving of criticism than the method itself. What are some of these abuses which encourage the possibilities of error?

Let us first consider the method of retaining the bearing point at the apex of the arch tracing. This is done by means of a hole that engages the bearing point. This hole should not be drilled in the plate on which the tracing was made. The tracing was developed on one plane. If you change this plane, you change the location of the apex of the tracing. The statement that it's a tiny hole doesn't help, for a tiny error is sometimes more troublesome than a gross error. The hole must be superimposed over the apex of the Gothic arch tracing.

Second, if the patient's jaw is to be retained or locked in position, the proper positioning of the central bearing point for equilibration of vertical contact becomes extremely important. One who uses this method must place the central point of bearing with care.

Third, users of this method would do well to caution their patients regarding the amount of pressure used in holding the bearing point in contact. Extreme biting pressures frequently encourage tilting of occlusion rims, a practice which results in errors in the centric relation record.

Fourth, if there are shortcomings in this method, they would be manifested mostly in patients presenting very soft yielding denture-supporting areas or in patients with excessive protrusion or retrusion.

DIRECT CHECK BITE METHOD

In this method, the operator, by manipulation, repeated trial, and observation, attempts to have the patient close in a position of centric relation. The interarch distance has been previously established by occlusion rims or teeth. The recording of the position is made with wax or other recording medium between the opposing occluding surfaces.

The two requirements of a centric relation record are: correct horizontal relation of the mandible to the maxilla, and equilibration of vertical contact.

With these requirements in mind, may we consider the direct check bite method. First, this method presents the possibilities of recording a position, with equalized contact, at a pressure determined by the displacement quotient of the recording medium, if, and I do mean *if,* the recording medium is of consistent texture throughout, and if the occluding surfaces are not permitted to penetrate through the recording medium. While several materials are suggested for recording, undoubtedly the most common one is wax. It is stressed that the pressure at which the record is made, and the degree of equalization of contact between the occluding surfaces, is entirely dependent on the consistency and the uniformity of consistency of the recording wax.

Second, the direct check bite method is the method used in securing a record for remounting finished dentures. Furthermore, it is the method we use to check or verify a position which has been mounted on an articulator. The question naturally arises—if this method is used as a means of checking, if it is good enough to use in remounting finished dentures, why is it not the one and only method for recording centric relation? To answer this, one can only give a personal viewpoint. I am inclined to believe that many operators find it more satisfactory to work with visible points of reference; hence, a direct check bite seemingly is easier when teeth which furnish multiple points as guides are present. At the occlusion rim stage of denture construction, the direct check bite method necessitates extreme care, judgment, and experience. Needless to say, the results produced by operators we all know show the possibilities of this method when it is correctly done.

I cannot leave the discussion of the direct check bite method without reminding you that, regardless of their choice of method in recording centric relation for the construction of dentures, there are times when the majority of operators make use of this method. The method is used for remount records, for checking the registration previously made, for cases with extremely abnormal ridge relations, or for cases of abnormal patient cooperation, to mention a few.

Because of this usefulness of the direct check bite method, every operator should understand the fundamentals upon which its successful use depends, even though one does not elect its use in routine procedures of denture construction. These are: (1) The ability to recognize the position of centric relation, through patient trial, recheck, observation, and so forth. (2) To keep in mind constantly the role played by the recording medium—its direct influence on the pressure developed in the recording, and the equilibration of the recording.

FUNCTIONAL RECORDING METHOD

The functional registration method, frequently called a chew-in, is a procedure, as the name implies, of letting the patient indicate the position of centric relation by functional movement. This procedure is accomplished with abrasive material on the opposing occlusion rims, wax between the occlusion rims, or by the use of studs which cut Gothic arch patterns in the opposing occlusion rim. It is another method for recording centric relation. It is a method with many good points but, like all the others, it is not infallible, but is dependent upon the intelligence of the user.

A brief consideration follows: First, in spite of the fact that its advocators claim the patient makes his own recordings, I am inclined to believe that the operator must possess a clear concept of that which he seeks to accomplish. The ability of the operator to determine when the record has been carried to a succesful completion is extremely important. The danger of perpetuating a habit is present in some cases. Second, the record is dependent upon the accuracy of the bases upon which it is made. Third, the method necessitates patient cooperation. Fourth, the record is developed under some pressure; hence, in patients with displaceable supporting tissue, the correctness of the method must be closely checked and verified by the operator.

SUMMARY

There are many excellent methods or techniques, all of which are capable of producing acceptable results. However, the criteria for final acceptance of their accuracy, I feel, are and always will be dependent upon the honesty, judgment, and intelligent vision of the operator.

The only purpose of this paper is the hope that it will stimulate more thought on the problems of centric relation. Thought which is static will never equal thought which is dynamic.

University of Michigan
Ann Arbor, Mich.

TREATMENT PLANNING FOR ADJUSTING ARTICULATION

RALPH H. BOOS, D.D.S.

Minneapolis, Minn.

ONE of the important responsibilities of the health service of dentistry is treatment planning for the entire dental occlusion. The ideal is a balanced articulation of a full tooth complement in harmony with the muscle forces, which includes the condylar heads in their normal positions in the glenoid fossae.

Cases of malocclusion, abrasion, periodontoclasia, extensive prosthesis, and facial pain or temporomandibular involvement are often presented which require treatment. All cases, even those without extensive involvement, are best examined with the entire articulation in mind. For those cases which require treatment, there are, fortunately, a number of procedures which may be followed.

Clinical evidence and roentgenograms are first obtained to establish the condition and value of each tooth. Accurate casts are secured to aid in the basic diagnosis. Vertical dimension and centric relation are registered. This is perhaps the most important step as this is the basis of the occlusion to be provided.

In this paper, we will emphasize treatment planning, but I would like to stress the importance of intermaxillary relation because the entire success may be dependent upon this registration. The centric occlusion as presented is recorded, but the intermaxillary relation registered for the diagnosis may be a physiologic relation which is rest position. The occlusion presented, in many cases, is a lost relation from normal, and by obtaining a physiologically balanced relation we will have the primary mandibular position. The occlusion can then be placed in harmony to that recording.

By recording physiologic rest position, we have established a vertical dimension, centric relation, and rotation center of the mandible. The rotation center is important as the mandible may be rotated up on one side or the other, or in front or back, by muscle pull to accommodate the occlusal conditions presented. Rest position also provides the neutral center of muscular forces as well as the location of the vertical level of maximum force. After the casts are mounted at rest position, the necessary free-way space may be determined and the centric relation and the orientation of the plane of articulation established. Centric occlusion is arranged in harmony with the mandibular movements in order to avoid thrusts or traumatic forces as the mandible moves from the neutral rest position to the position of occlusion.

Other methods of intermaxillary relation registration may be used and one procedure examined in comparison to the other in order to provide a basic diag-

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nosis to be used for the mandibular position. An unstrained jaw relation is a definite advantage in the correct placement of the mandible. Materials such as plaster do not require force for registration. Wax or modeling compound check bites may record strained relations, just as would pressure on a central bearing point.

The articulation of the teeth has a significant effect on the position of the condylar heads in the glenoid fossae.

Many times, a primary diagnosis can be made from the casts mounted in the proper centric relation. When desired, condylar path records are made to provide an adjustment of the horizontal condylar guidance on adjustable articulators. Those who use an articulator designed on the spherical principle do not require this type of registration. A face-bow transfer is used for mounting the casts on the articulator. These latter steps are most important for a thorough diagnosis.

Following the mounting of the casts on the articulator, the relation of the mounted casts to the occlusion presented is studied to determine the path of closure and to determine the relation of the existing occlusion to the mandibular position desired. Primary contacts and selective grinding may be indicated which would place the articulation in a greatly improved balance. Some cases are presented in which a tooth movement or orthodontics would greatly aid the occlusal harmony. Other cases may require an opening or building up of the occlusion, together with some prosthesis.

The term "opening a bite" is misleading in that the operation should be one of restoring the vertical dimension and the working occlusal surfaces.

There have been cases of failure which have been attributed to increasing the vertical dimension. An analysis would indicate that many of the failures proved to be due to a centric position which was incorrect and a lack of balanced articulation and not to increasing the vertical dimension.

When the primary diagnosis of centric relation is correct, we may predetermine the relative amount of biting force by the free-way space. The normal free-way space is 2 to 4 mm. A greater free-way space reduces the biting force. The articulation may be analyzed by a comparison of the abrasion of the teeth or by the cuspal relations presented in the path of closure to a normal centric relation.

There is so much to be gained in the treatment of dental cases, some of which include temporomandibular involvements, that a thorough study should be made of every case. Some of the procedures which may be followed in treating these cases are as follows: (1) conditioning of the patient, (2) orthodontics, (3) selective grinding, (4) occlusal guide splints of acrylic or metal (a temporary treatment), (5) fixed prostheses, which include inlays, crowns, and bridges, (6) removable restorations which include occlusal pad guides, (7) surgery following an analysis of jaw relations on mounted casts.

CONDITIONING OF THE PATIENT

Before the technical procedures are begun, the patient should be conditioned to facilitate the recording of maxillomandibular relations and to understand the treatment planned. This may involve psychology as well as physiology. The mental attitude of the patient toward dentistry and the understanding of his condition is carefully considered. He should appreciate a rest position of the mandible and the free-way space. By having the patient aware of the free-way space, less tension will be placed on the natural teeth and on the reconstruction. There may be tensions and habit patterns which should be released before registrations are recorded. Usually, this would require exercise of the mandible a number of times a day for a few days before the registration is recorded. In severe cases, hot packs are used on the sides of the face, including the area of the temporomandibular joint. Sometimes sedatives are helpful for producing relaxation. A conditioned patient is an aid in attaining a successful result.

PLAN OF TREATMENT

Basically, all the technical procedures for restoring occlusion are involved with the same principle, an orientation of the occlusal plane. The relation of the anterior teeth and the relation of the posterior teeth may be considered separately although they are involved in the same articulation.

When there has been an anterior contact, even though there is a vertical overlap, it is necessary to maintain an incisal contact in the restorative procedure. The amount of overlap is determined by the vertical opening. At times it is not possible to establish a vertical dimension which will avoid an unusual vertical overlap. However, the lower incisal edges must contact the lingual surfaces of the upper central incisors in centric position if there has been a contact there previously. If this contact is not maintained, there is a possibility of extrusion of the teeth, causing a traumatic condition.

Fortunately, in many cases, the new centric position permits a contact of the anterior teeth even though the vertical dimension has been increased. This is because the occlusion presented forces the jaw distally upon closure. When the normal centric relation is established, the jaw moves forward without the deviation produced by the malocclusion, and the anterior teeth maintain their normal contact.

If there has been no anterior tooth contact, it is not so important that there be a contact at the new jaw relation. Ordinarily, the tooth position is maintained even though there is no contact to hold the teeth in position. Usually, when contact is required on the lingual inclines of the upper teeth, inlays or onlays are placed on these surfaces to create the desired condition. It is possible to have this relation established by part of a removable restoration.

The posterior relation of the teeth to the occlusal plane is first examined by the application of an imaginary curve of Spee carried back from the incisors. This provides a general picture of the tooth height required in the posterior area. (The curve of Spee is an arcuate line from the lower incisors to the top of the

retromolar pad which touches the tips of the buccal cusps.) The loss of vertical height of the individual tooth by malposition or shifting is noted. As the case progresses for actual construction, the curve of Spee becomes the compensating curve. The various angles of the cusps and the working occlusal surfaces must be created to provide a balanced articulation. The orientation of the working occlusal surfaces is dependent upon the remaining teeth and the tooth height desired.

ORTHODONTICS

Perhaps the most ideal treatment is orthodontics. The result may be attained by this means without tooth preparation or prosthesis and a lasting benefit provided. Unfortunately, many cases are presented in which orthodontics is contraindicated due to age and other conditions. There are, however, cases in which minor orthodontics would be helpful in attaining a better result. If the treatment were activated originally at the proper time, many difficult cases could be prevented.

SELECTIVE GRINDING

The condition of the teeth present, the related structures, the leverages, and the biting forces may be evaluated to aid in predetermining the treatment. Generally, a three-dimensional occlusal plane is provided either by selective grinding, operative dentistry, or prosthesis. A three-dimensional occlusal plane is formed by the height, width, and depth of the cuspal angles and the incisal guidance. There are some procedures which use a two-dimensional occlusal plane. These involve the use of flat cusps on the posterior teeth which provide the height of the occlusal plane and width of the masticating surface, but do not provide cusp height.

In those cases in which no change in vertical dimension is required, selective grinding may produce the desired result. Traumatic occlusion may be relieved, and a much improved balance of the articulation may be obtained. Selective grinding is an excellent method to use when it is possible, as it does not involve the extensive restorative work that is necessary in some cases.

The primary contacts upon closure into centric position are noted in their relations to contacts in the lateral and protrusive movements. To provide a balance of tooth contacts on the working side with those on the balancing side, as well as in centric position, involves the selection of cusps or sulci to be ground. This selection depends upon the relations of the teeth in all the various contact positions within the functional range. Balanced occlusion may be developed without changing the vertical dimension by grinding the proper cusps or sulci. Selective grinding is often facilitated by first grinding the teeth of the casts on the articulator and then noting the sequence of this grinding to obtain the final result. By carrying the same sequence of grinding to the mouth, the process may be facilitated. The literature contains excellent material on this type of occlusal correction which is very helpful for a detailed study of selective grinding.

OCCLUSAL GUIDE SPLINTS

Occlusal guide splints are very helpful in providing a mouth test of the selected occlusion. They are constructed of acrylic or metal and are placed over the remaining teeth as they are presented. No preparation or grinding of the teeth is necessary so the case may be returned to the original occlusion if the proposed rehabilitation is not satisfactory.

The construction is done on the casts which have been mounted on the articulator. The occlusal surfaces of the crowns of the teeth are covered by the splint. The compensating curve is established at the proper orientation on the occlusal surface of the splint.

Sometimes both upper and lower occlusal guide splints are necessary. This situation would require four individual splints, one for each side of the lower arch and one for each side of the upper arch. Many times the upper posterior teeth present a reasonably normal occlusal plane, and splints are required only on the lower jaw. The splints are cemented to position to provide a more comfortable test pattern. Acrylic splints may be used for only a short time as they have a tendency to wear away and may not maintain the desired occlusal plane. Metal splints (usually of silver) may be worn for quite a number of weeks. As long as they are carefully cemented and cleanliness is maintained, there is not too much danger of caries. However, if they are used over an extended period of time, they may be dangerous to the crowns of the teeth.

FIXED METHODS

Splints provide a convenient method of rebuilding a case by the fixed method. A part of the splint may be cut off and the exposed area built to the occclusion desired, while the remaining occlusal splint guides maintain the occlusal relation. In this type of work, the mouth is used as the articulator.

Another fixed method for adjusting the articulation is to make preparations for restorations in the teeth as indicated by a study of the articulated casts. Impressions are made of the individual preparations, either by the hydrocolloid method or other procedures, and casts are made with dies of the prepared teeth in place.

A registration platform is constructed on this cast, and the intermaxillary relation is registered. The orientation of the occlusal plane is established by a mean plane which would divide the occlusal gap if both upper and lower teeth require reconstruction, or only the teeth of one jaw are reconstructed against the remaining occlusion. In many cases, only the teeth of the mandible require reconstruction. The entire rehabilitation may be planned previous to any operation, and an estimate can be made of the steps required.

REMOVABLE RESTORATIONS

Removable restorations, which include occlusal pad guides, may be used to balance the articulation. The occlusal pad guide is a removable restoration which rests on a natural tooth to create the height and type of occlusal surface desired. The removable restoration will replace the missing teeth and include occlusal pads wherever necessary to build the occlusal plane up to the desired orientation.

As the appliance is removable, it is more or less the responsibility of the patient to maintain cleanliness and avoid caries. Should caries occur, the filling may be made in the tooth under the pad, or the occlusal pad may be removed from

the partial denture and the individual tooth built up to occlusion as an individual restoration. The removable restoration provides a rather inexpensive immediate treatment for rehabilitation cases.

No tooth preparation is required except as is necessary for the partial denture replacement. Often there are cases which are presented for partial dentures, but, by the use of proper intermaxillary relation registrations and the addition of occlusal pads as indicated, the restorations produce rehabilitation. Many times the removable partial denture will provide a long service because no extensive tooth preparation is involved.

SURGERY

In patients with extremely unfavorable jaw relations, surgery may be indicated as a treatment to create a more nearly normal articulation of teeth and to achieve an esthetic improvement. A careful analysis of the jaw relations from rest position and the possibilities of restorative dentistry should be explored before surgery is planned. Some prognathic cases are greatly improved by increasing the vertical dimension because the mandible moves downward and backward as it is opened. When surgery is planned, casts are articulated in the relation of the proposed surgical result. Splints are constructed or wiring is planned in cooperation with the surgeon in order to facilitate the process.

Much of the rehabilitation treatment could be avoided by early care and preventive dentistry. The loss of a single tooth without replacement may cause a collapse of the dental arch and a shifting of teeth which may result in a damaged dental occlusion, periodontoclasia, and perhaps temporomandibular disturbances. Today, people are more desirous than ever of maintaining dental health and function. Dentistry is able to provide a treatment for many of the dental anomalies.

This summary of treatment planning provides a general classification of the various procedures which may be used in adjusting articulation. There are many individual techniques which may be followed for the treatment of faulty articulation. Fortunately, many men have suggested techniques in the literature which provide a background of study for each procedure which may be used.

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808 Nicollet Ave.
Minneapolis 2, Minn.

STUDIES IN ARTICULATION

CHARLES H. MOSES, D.D.S., M.Sc. (DENT.)

Faculty of Dentistry, University of Toronto, Toronto, Ont.

THERE is still a great deal of confusion and misunderstanding about the subject of articulation. Clarification is necessary on a number of phases on the subject. This will come when the approach to them is from many directions. That is how perspective of a subject is achieved.

Although much of the material presented today may be of a controversial nature, it represents another approach—another viewpoint. Controversies disappear with understanding. They are present only because knowledge is incomplete. It is the sincere hope of your essayist that some of the material presented will help to dispel the haze.

There is an interrelationship of several studies on articulation. Although at first glance some of these appear to have no bearing on complete denture prosthesis, further investigation proves that a relationship does exist. An attempt will be made to investigate and relate several factors which have a bearing on the subject of articulation.

ARRANGEMENT OF TEETH

The question of tooth arrangement has been the subject of a good deal of controversy. Monson[1] presented a pattern that is generally accepted. He stated in effect that if a sphere with a diameter of 8 inches were to sit on the mandible, all the biting surfaces would be flatly contacting (Fig. 1). Although the measurements are not actually adhered to, except by a very small group, the general scheme of the tooth arrangement is fairly well followed. Monson's approach was so mechanical that he also believed that the condyle contacted the sphere on the same circumference as the teeth.

At this point, it is important that the term "pitch" be defined. There can be two interpretations of pitch. For instance, the vertical axis of a tooth inclining lingually could be said to have a lingual pitch. This is *not* what is meant in this paper. In order to avoid confusion, pitch will refer to the occlusal surfaces of either teeth or occlusion rims. We shall soon see that unworn occlusal surfaces may incline either buccally or lingually and be approximately at right angles to the long axis of the tooth. When wear takes place on that occlusal surface, the inclination of its surface may alter, making an acute angle with the long axis of the tooth. Thus the pitch would be altered.

The upper teeth with the Monson type of arrangement would, therefore, meet the lower teeth by presenting a convexity toward the mandible. This

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formula is generally accepted as normal tooth arrangement. Prosthodontists set up their artificial teeth to that design, and orthodontists attempt to bring the teeth of their young patients into that pattern. It appears to be the generally accepted formula.

It may be observed, however, that there are many exceptions to this pattern in nature. For example, Dr. C. H. M. Williams, of the University of Toronto, took impressions of the mouth of a 23-year-old Eskimo girl. The maxillary arch (Fig. 2) had a positive anti-Monson pitch as did the mandibular arch (Fig. 3).

Many primitive people have a reverse pitch buccolingually to that of the Monson pitch. The term Monson pitch shall be used in this paper to denote the generally accepted pattern of the occlusal pitch. The opposite pitch will be called the anti-Monson pitch.

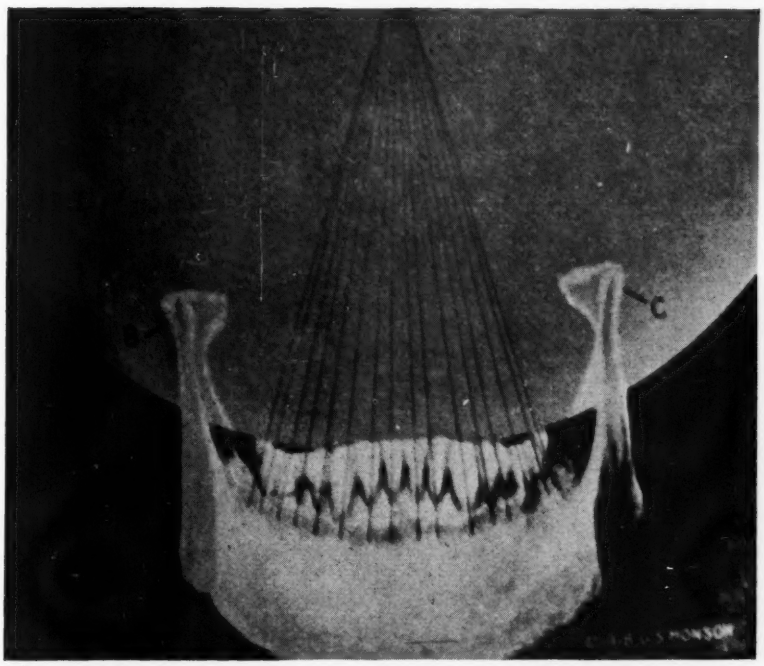

Fig. 1.—Monson presented a formula which stated in effect that if a sphere with a diameter of 8 inches were to sit on the mandible, all the biting surfaces would be flatly touching. The condyles would also be in contact. (From Monson.[1])

HUMAN AND ANIMAL TOOTH ARRANGEMENT

Formula in the Arrangement of Natural Teeth.—In an attempt to discover a common factor, your essayist investigated a great number of human skulls, animal skulls, and casts of the teeth of Eskimos and Indians. This study produced a law that appears to be constant. This is the law: *"Under normal conditions a natural posterior tooth inclines in the direction of the ridge opposing it."* Particular care is taken not to state that *teeth* incline because in the same mouth and on the same ridge two different inclinations may be seen on two different teeth.

Study of the Arrangement of Animal Teeth.—On examining the teeth of the zebra, the sheep, and the deer (Fig. 4), it was found that the maxillae are broader than the mandibles. It is logical to expect that the teeth of both jaws should incline toward each other. They must meet in order that the animals may masticate food. Therefore, the maxillary posterior teeth have a lingual pitch, while the mandibular posterior teeth have a buccal pitch. These three animals definitely have an anti-Monson pitch.

Fig. 2.

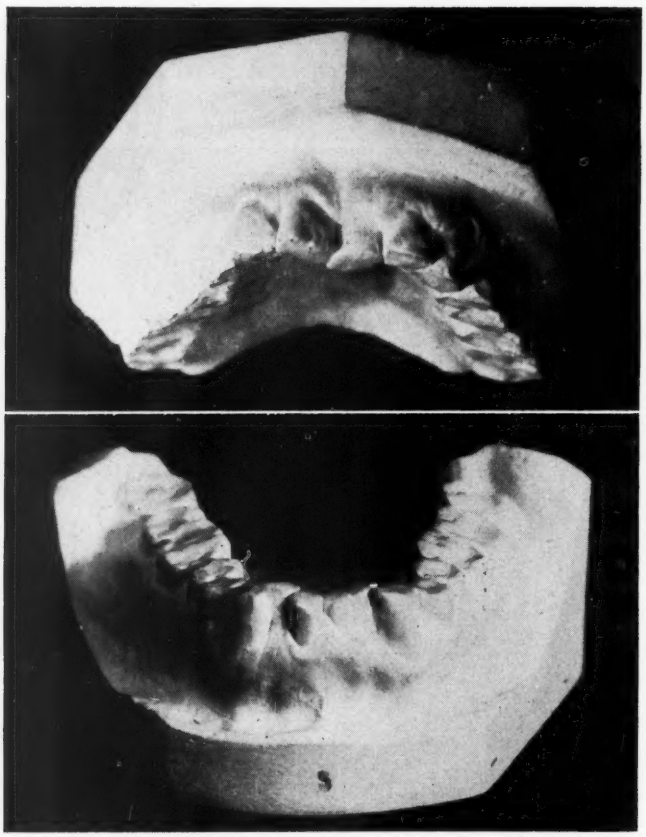

Fig. 3.

Fig. 2.—Upper cast from impression of a 23-year-old Eskimo girl made by Dr. C. H. M. Williams of the University of Toronto. The pitch is anti-Monson, and the wear is chiefly at the expense of the upper lingual cusps.

Fig. 3.—Lower cast from same mouth as in Fig. 2. The pitch is anti-Monson, and the wear is extensive and chiefly at the expense of the lower buccal cusps.

In the beaver, the mandible is broader than the maxilla, and the upper posterior teeth have a buccal pitch while the lower posterior teeth have a lingual pitch. This is similar to the Monson pitch. The capybara is also a very good illustration.

Lest the conception be formed that the pitch is influenced by the path in which the occlusal surfaces of the teeth travel, let us examine the capybara (Fig. 5). The shapes of the condyles and the fossae suggest that the animal has an anteroposterior movement, yet the pitch is quite steep.

Fig. 4.—The teeth of the deer. The maxilla being uniformly broader than the mandible, an anti-Monson pitch of the teeth is present.

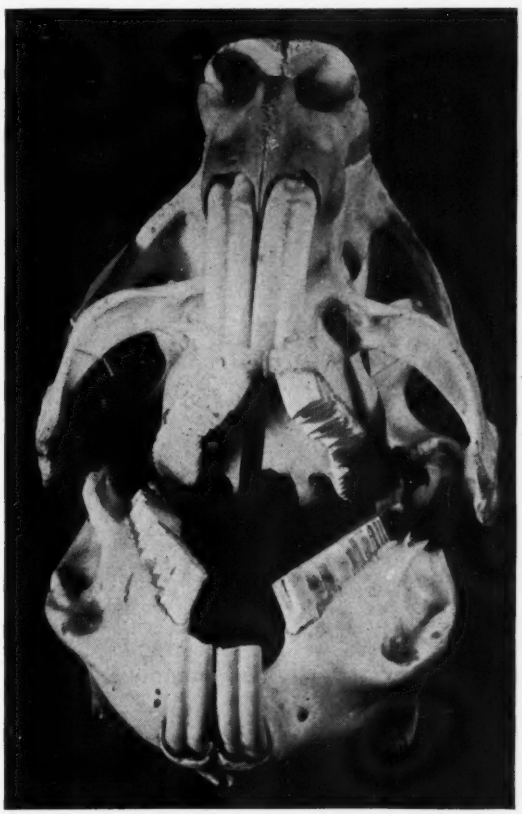

Fig. 5.—In the capybara, the mandible is broader than the maxilla; the teeth, therefore, present a Monson pitch. This animal has an anteroposterior chewing motion, like all rodents, proving that the pitch has little to do with chewing motions.

Now let us examine the bear. Being carnivorous in origin, although becoming omnivorous by adaptation, it has a hinge joint. Carnivora have hinge joints that permit only opening and closing movements with no lateral or protrusive motion. The anterior teeth are, as a rule, so interlocked that even minute movement other than centric closure is prohibited. On examination of the mandible, however, the last molar tooth will be seen to have a lingual pitch while the other posterior teeth have a buccal pitch (Fig. 6). Correspondingly, the upper last molar tooth, which is a compound tooth and articulates with the last two lower molar teeth, has a buccal pitch on the posterior part of the tooth and a lingual pitch on the anterior portion.

Fig. 6.—Like all other Carnivora, the bear can only open and close on the hinge joint, yet the pitch on the last molar tooth of the mandible is lingual while the pitch of the other posterior teeth is buccal. The relative width of the opposing ridges determines the pitch.

This is explained by the fact that the mandible is wider than the maxilla in the region of the last molar tooth while the maxilla is wider than the mandible in the other molar regions. An examination of a monkey discloses a maxilla that is broader than the mandible. The same rule holds true; the maxillary posterior teeth have a lingual pitch and the mandibular posterior teeth a buccal pitch.

The rabbit has an anti-Monson pitch while the white rat has a Monson pitch. The rule holds true in all animals examined, from the elephant to the mouse.

Study of the Arrangement of Human Teeth.—Upon examining the skulls of human beings, it became evident that apparently Monson had not investigated the skulls of primitive people. In many primitive skulls the pitch is definitely anti-Monson. The skulls of the Zulu and Bushman (Fig. 7) show teeth with a definite anti-Monson pitch.

In primitive children the rule is observed more easily because of the anti-Monson pitch of most of the molars. For example, in a child of 5 or 6 years

the lower first permanent molar erupts lingually (Fig. 8). Its pitch is lingual long before it makes contact with the opposing tooth. The deciduous molars have, more or less, a buccal pitch. The opposite is, of course, true of the maxillary teeth.

Fig. 7.—Skulls of a Zulu (left) and a Bushman. The pitch of the teeth is anti-Monson.

Fig. 8.—The lower first permanent molar, being at the widest part of the mandible and wider at this point than the maxillary ridge, has a lingual pitch. The deciduous molars have a buccal pitch. (Cast from impression made of an Eskimo child by Arkle on Belcher Island in Hudson Bay.)

The reason for this appears to be that, when it erupts, the lower first permanent molar is situated nearest to the angle of the mandible. This is the widest part of the mandible. The maxilla narrows at the tuberosity, making the mandible broader than the maxilla at that point and accounting for the pitch of the corresponding last teeth.

When the child reaches 11 or 12 years of age and the second molar erupts, *it* now has a lingual pitch while the molars anterior to it become more buccal or horizontal in pitch.

When the lower third molar erupts, it will have a lingual pitch while the second and first molars have a buccal pitch, as we see in the adult Maori (Fig. 9).

It seems reasonable to deduce from these studies that the orthodontist must study this law so that he may move the teeth to positions in accordance with the law. The dentist who concerns himself with occlusal reconstruction should consider this law carefully. Let us repeat the law: *"Under normal conditions a natural posterior tooth inclines in the direction of the ridge opposing it."*

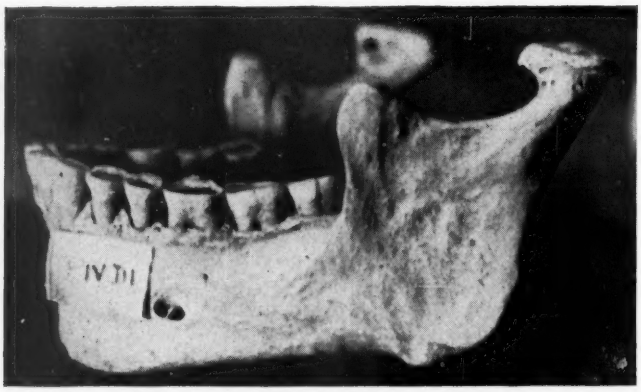

Fig. 9.—Mandible of a Maori. Note the differences in pitch, the tooth nearest the ramus is lingual, while the other posterior teeth gradually become buccal.

FUNCTION AND ITS INFLUENCE ON THE ARRANGEMENT OF TEETH

There seem to be several laws that are concerned with function. There is apparently an economy in nature, a functional economy. This is true of both the hard and soft tissues. It is well known that both bone and muscle will hypertrophy with increased function if the nourishment is good. A blacksmith will develop large biceps as he wields his mighty hammer. The bones become correspondingly bigger and more developed. Conversely, when tissues are not used, atrophy will occur. In a bedridden patient the bones lose some of their calcium salts and become radiolucent. In time the bones and muscles atrophy from dysfunction.

Bone has the ability to organize its trabeculae into patterns or architectural designs to meet force. It will rearrange these patterns if either the direction or the intensity of force is altered. Wolff's law (Fig. 10) describes such a pattern, although others before and after Wolff have given similar or modified theories. It is now believed that Wolff's law is not absolutely accurate, but the general idea that tissues alter to meet function still holds true. These laws act in the mouth and associated structures in the same manner that they do in the rest of the body. Function is an important factor in the development of the entire mandible as well as the maxilla, including the condyles and the mandibular fossae. Heavy function will, if the factors of maintenance are adequate, cause hypertrophy of the bony structures concerned, while light function will reduce the bony structures in keeping with the degree of function. That is the economy of function in operation. Heredity is also a prominent factor in in-

fluencing size and shape. Discussion of heredity in this paper is not within the scope of this treatment of the subject.

Prosthodontists appreciate well-developed ridges. These ridges appear to coincide with function. End-to-end occlusion of the anterior teeth seems to give the type of stimulation to natural teeth and associated structures which is conducive to the formation of broad high ridges. Civilized man has a tendency to by-pass the anterior teeth. He cuts off a piece of food with a knife and fork and places the food on the posterior teeth. Consequently, as a rule the anterior ridges are not so well developed.

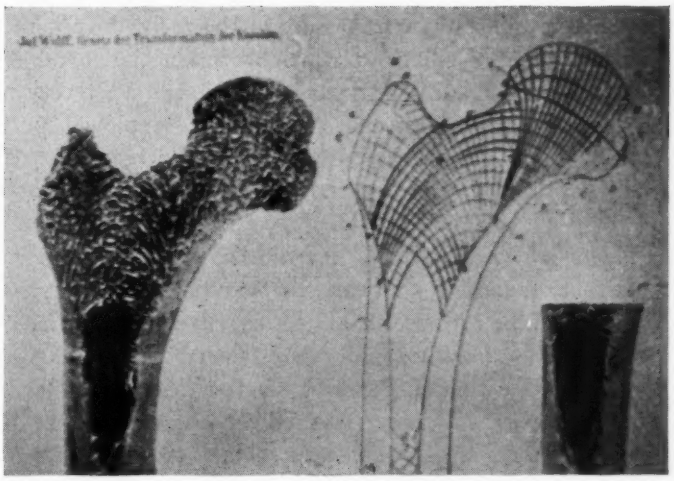

Fig. 10.—Wolff's law. Cross section of the head of a femur showing the arrangement of bone along definite lines of design. The schematic drawing shows more clearly the manner in which the bone is constructed to take up strains and resist stresses.

Examination of the skulls of primitive people shows that they nearly always have an end-to-end occlusion in the anterior region of the mouth or one very nearly so. Another interesting observation is that these people have heavy coronoid processes. The cause may be traced to function. The temporal muscle is inserted into the coronoid process. The posterior fibers help to retract the mandible. When the anterior teeth are employed in biting off food, retraction of the mandible from a protrusive position takes place. Of course, these people also have tougher food which requires more force in closure, and therefore this calls upon the temporal muscle to exert pressure also in an upward direction. The coronoid process is thus stimulated by the heavier duty performed by the temporal muscle.

Civilized people have thin coronoid processes. They require less force in mastication and rarely have to retract the mandible forcefully in biting off tough food. This lack of function in civilized man also causes steep vertical overlaps. In some instances, there is little or no horizontal overlap. This is still in keeping with the economy of function. With softer diets very little lateral movement is required. Vigorous incisive action is rarely necessary. Consequently, eccentric movements are not performed frequently. Observe a person

eating one of the jelly desserts. He scarcely moves the mandible. This type of food is swallowed without mastication. This is another form of functional economy. With tougher food more lateral and protrusive movements will be made. Teeth will fall into different positions because of different degrees and types of function. Should a toothache or another cause make it inconvenient to chew in the habitual manner, eccentric jaw positions may be acquired to avoid this inconvenience. The eruption of teeth will still continue, and a false centric occlusion may thus be established. This false centric occlusion will be observed only upon closure.

When we consider that we normally close our teeth a small percentage of the time and that in the normal rest position the teeth do not meet at all, we can see that the forces of equilibrium which maintain the mandible in a fairly constant relationship to the maxilla in rest position do not alter very much. These forces must not be confused with those which are employed during function. The latter will be employed in keeping with the function required. They, in turn, will be causative factors in altering the shape and size of the soft and bony structures.

For example, if a person changes his dietary habits from a soft food type like civilized man's to a hard food type like that of the Eskimo, the trabeculae of the bone will reorganize to meet that function, altering the shape of the bones that are employed. The muscles will also hypertrophy, and the periodontal membranes of the teeth will organize to meet the load. The teeth may therefore be driven into altered positions. The condylar paths will probably alter to meet these new requirements. Bone has the ability to change its shape to meet new forces. This is a well-known fact.

On the other hand, the rest position may not have been altered very much since the mandible resumes its accustomed position when the teeth are not in contact. The teeth meet during mastication, during swallowing, and sometimes during conversation. (We are not considering the subject of bruxism in this paper.)

The evaluation of function is important from the standpoint of occlusal reconstruction. Will the natural teeth whose occlusal surfaces have been reconstructed into the ideal articulation for that mouth remain in that position? Will not altered function or altered forces, because of the new articulating surfaces, cause a reorganization of the bones and periodontal membranes? If there is a reorganization, will not the articulation alter again? Will not the condyle paths alter? Or will the status quo be maintained because these forces which cause the reorganization will compel the bone to form into a pattern in keeping with the new direction and force? It must also be remembered that the condylar paths are utilized just as they are found in the technique employed in occlusal reconstruction and that the articulation of the teeth is reconstructed to conform to these paths. The chances are, therefore, that the condylar paths will remain constant. What effect has function, due either to arrangement of teeth or to altered diet, upon the shapes and sizes of ridges, condyles, and mandibular fossae in complete dentures?

It would seem that if dentures are constructed without having a tooth arrangement which conforms to the condylar paths, alterations will take place in the condyles to meet the new function, which will be a physiologic reaction; ridge resorption will take place due to pressure atrophy, which will be a pathologic reaction.

WHAT DO MEAN BY NORMAL, PHYSIOLOGIC OCCLUSION?

Our studies up to now illustrate why "normal occlusion" could be such a variable term. It would largely depend upon the function and other factors. Many elements enter into the picture. Metabolism is a strong factor and could easily upset a general law. Heredity is another factor. For example, one might inherit the general size of the skull from one parent and the size of the teeth from the other. They might be inharmonious. Infection, caries, and accident may all play their part in altering occlusion.

The term "normal" should embrace all these possibilities by indicating the manner in which, by natural laws, adjustments are made. The masticatory function of an Eskimo child would be quite different from that of the average white child. The direction and intensity of forces would, therefore, be quite different. Tooth arrangement in keeping with these laws would be different. Thus, normal would appear to be quite different for an Eskimo child than for a white child, yet the same laws would operate. It is because of these laws that the appearances are different. Should not the definition of "normal" include phraseology that indicates the operations of these laws?

Normal may vary with the same individual at different stages of life. Normal may vary with changes of function, as illustrated in Box's book, *Twelve Periodontal Studies.*[2] It may be seen, therefore, that the term normal is not a static one. It should not be static because the environment consisting of habits, metabolism, function, and so forth is not static. The only constant features of normal occlusion are the laws that operate.

The orthodontist, the periodontist, and the prosthodontist must, therefore, learn these laws and develop studies on them so that the condition and treatment of the patient's teeth may better be dealt with. The orthodontist must not only know the laws of articulation and move teeth into positions that conform to these laws, but he must also study the laws that influence the angulation of teeth.

If function plays a part, an estimation of the function of the individual should, perhaps, be made. Teeth should be positioned with that in mind. The prosthodontist and the periodontist have also the problem of keeping the function and dentition of the patients in a harmonious relationship.

THE WEAR OF TEETH

The subject of wear is a controversial one. There is a school of thought that believes that the wear of teeth is a pathologic process. This school, whose most vigorous exponent appears to be Dr. B. B. McCollum of Los Angeles, be-

lieves that wear is a degenerative process. These dentists go to great length to build up beautifully articulating surfaces, by means of metal cusps, and to "restore physiologic function."

Box, an outstanding periodontist, on the other hand, claims that wear, to a degree, is beneficial to the bone, periodontal membrane, and gingiva. He based this observation upon more than thirty years of clinical experience, backed up by thirty years of research. He began the study of occlusal equilibration in 1917 and has seen many mouths which were considered hopeless years ago placed by treatment, which included judicious grinding, into a very healthy condition today. That does not say that he does not recognize that there are conditions where occlusal equilibration (a term which he originated) may best be accomplished by artificially constructing proper articulating surfaces, either of metal or porcelain.

Man has had wear of the teeth for millions of years. The fine particles of grit which were mixed into his food caused most of this wear. Since it is only in the past few hundred years that the abrasive elements in the foods have been removed from the diet of civilized man, this may well be ignored. A few hundred years, as against several million years, is insignificant in studies of evolution. We cannot, therefore, consider unworn teeth as the normal. An animal performs in only two ways in meeting a pathologic process. It either becomes extinct, or it builds a defensive mechanism. Man is still here. If he will become extinct, it does not appear at the moment that the wear of teeth will be the cause. He is devising more lethal weapons. Perhaps the process of continuous eruption, as shown by Gottleib, is the compensating mechanism that man is developing. There seem to be other factors that are not only compensating but also beneficial. The pulp seems to have an organization to meet wear. The periodontal membrane also seems to have that ability. This is evidently an evolutionary result. The very pattern of wear appears to be so designed that axial loading is induced. This type of loading is beneficial and tends to keep the stress on the tooth within physiologic limits as we shall soon see.

We shall not consider in this paper the pathologic type of wear where teeth wear down to the gingiva or wear past the contact point. Wear begins early in primitive children. Eskimo children exhibit wear in their deciduous teeth (Fig. 11). Adults generally show wear at the expense of the upper lingual cusps and the lower buccal cusps. In the mouths where teeth have a Monson pitch, this produces a horizontal pitch during one stage of wear, while in a further stage of wear it produces an anti-Monson pitch. An original anti-Monson pitch will, of course, be accented with wear. In Fig. 12 the pitch was apparently horizontal originally. With the extraction on the right side, the chewing was performed chiefly on the left side. The abrasive character of this Eskimo's food accented the pitch on the left side.

It had been considered that this anti-Monson pitch produced by wear was caused by chewing motions or mandibular movements. This is not true. It may be produced when only a hinge motion is present. Since the upper buccal cusp overlaps the lower buccal cusp horizontally and the lower lingual cusp overlaps

the upper lingual cusp horizontally, they do not wear as much as the surfaces in common contact with an abrasive substance. Consequently, the surfaces most frequently contacting abrade the most. These are the lower buccal cusps and upper lingual cusps (Fig. 13).

Fig. 11.—Wear on deciduous teeth of Eskimo child from impressions made by Arkle of the University of Toronto.

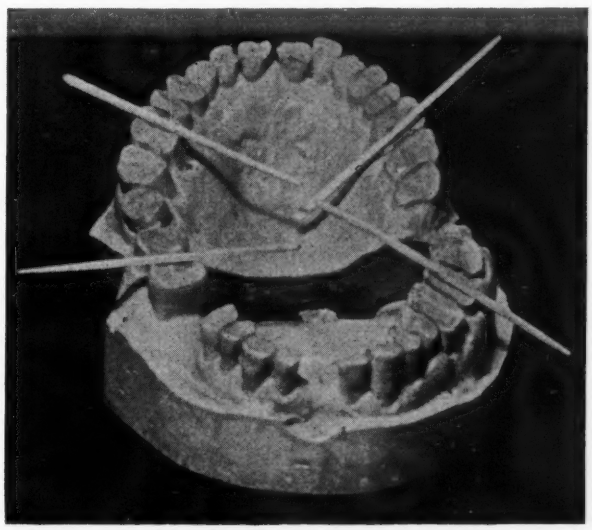

Fig. 12.—From impression of an Eskimo adult made by Dr. R. G. Hemmerich of Kitchener, Ont. The difference in pitch of the patient's left side is probably due to greater chewing activity since two molar teeth were extracted on the right side.

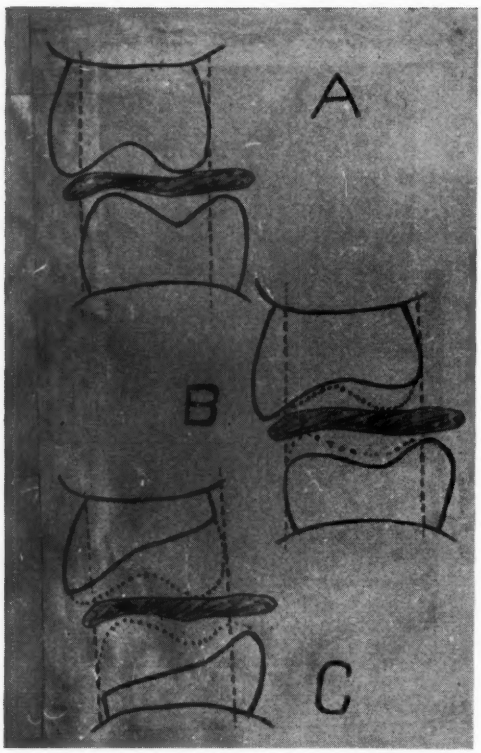

Fig. 13.—Wear takes place chiefly on the common contacting areas between the dotted lines.

DISCUSSION OF SHEARING EFFICIENCY

If we are to judge whether wear is physiologic or pathologic, it would appear reasonable to expect that the tissues involved should divulge the information. What should we examine and what should we expect to find? In the first place, we would expect that the vital tissues would give us some clues. If the vitality and the physiology of the pulp tissue are maintained, if the gingival tissues appear to be robust, if the periodontal membrane is well organized, and, above all, if the bone is heavy, the condition could be interpreted as being physiologic. In the second place, masticatory efficiency could also be used as a guide. Cusps contribute to shearing efficiency. One incline plane sliding upon another at an oblique angle is believed to have an efficient action. Cusp meeting cusp is said to be an efficient method of biting through food at the beginning of the masticatory stroke. Should not the obliteration of cusps decrease the efficiency? One would think so. One would think so, that is, until one investigates the eating habits of primitive people. An Eskimo can bite through and comminute meat that a "civilized" person could scarcely dent, let alone grind, with his "efficient" cusps. He certainly has efficiency. How does he obtain this efficiency?

We will not discuss all the elements that are included in the subject of shearing efficiency. It is evident that a longer glide will, to a degree, compensate for lost cusps. As cusps wear out, the Eskimo makes up the deficiency by increasing the glide. It is evidently very satisfactory for an Eskimo. He has developed the musculature and bones for the added work. This is, of course, reciprocal. The added work has developed the musculature and bones. Without this reciprocal arrangement, it is doubtful whether wear could prove successful.

That is why the introduction of cuspless teeth, both natural and artificial, into the mouths of people whose general maintenance level is too low may result in a breakdown of the supporting tissues by increasing the load. In these cases greater benefits would be derived by reducing the work required and by increasing the masticatory efficiency.

Worn teeth in young, healthy people, with a good blood supply to the parts, would induce heavier bone, musculature, and supporting tissue. This is amply illustrated by examining casts and skulls of people with worn dentitions.

There is this factor to consider, though, when planning occlusal reconstruction. If the efficiency becomes so great that a minimum of work is required, there might be a reduction in size of all the supporting tissue if this tissue had been hypertrophied because of wear. This is a form of disuse atrophy. This is another example of the economy of function.

LOADING AS RELATED TO ATROPHY AND HYPERTROPHY

Whenever wear has occurred, the alveolar bone is heavy and broad with a generally good picture of the periodontium. The gingiva is generally of good appearance, and the attachment of the epithelium is high. Wear seems to encourage an end-to-end occlusion, although that is not always achieved. Increased function of the anterior teeth may also be associated with wear and an end-to-end bite. This increase in function will not only cause an organization of the trabeculae, but will encourage a physiologic hypertrophy of the bone. Perhaps, at this point, it would be advisable to discuss hypertrophy and atrophy just a little further.

Hypertrophy is an enlargement. There may be degrees of hypertrophy. Let us consider only physiologic hypertrophy. There are other types with which we shall not concern ourselves here. In muscle or bone, hypertrophy is associated with heavy function. In younger people with a good blood supply, which is another way of saying with proper nourishment, an increase in function will produce hypertrophy. Conversely, whenever we observe hypertrophic tissue, we may suspect either heavier function or heavier loading within normal physiologic limits.

Atrophy may result from a number of causes. We shall deal only with functional atrophy. Having observed the economy of function, we can expect that muscle and bone will reduce in size in proportion to the function. Arms and legs, when placed out of function, develop thinner bones and smaller muscles. This is an atrophy of disuse.

Another type of atrophy may occur when the work becomes too great for the maintenance level of the tissues. Overfunction then becomes destructive. Depending upon all the factors that produce the maintenance level of the tissues, function may be adequate at one time and too great at another. When it is too great, atrophy occurs.

When a vertical overlap is present, there is, as a rule, a different picture of the bone and the gingiva than when an end-to-end tooth relation is present. We are, of course, speaking of mouths with the natural and the usually malarticulated dentitions. As a rule, the ridge is thin, and the wear is negligible. The general function in these cases is limited. The very position of the teeth indicates that fact. Had the anterior teeth been used more frequently, their relations would have been nearer to an end-to-end position. When they do meet in an eccentric position, the force of occlusion may be too great for some of the teeth; this results in overloading. Peridontal lesions are, therefore, more frequently observed in these cases. Hay,[8] at the University of Toronto, showed that the increase in force from vertical or axial loading to lateral or oblique loading is significant. This is illustrated diagrammatically with cones to represent teeth. If 3 ounces of pressure at the incisal edge are directed in line with the long axis of the tooth, they will resolve into 22 pounds per square inch at the apex. As Box[2] said: "If we assume that the limit of safety for the tissues is approximately 25 pounds per square inch, we see that the pressure at the apex is within normal physiological limits." This will have a stimulating effect. If there is oblique loading and the 3 ounces of pressure are directed at an angle of 45 degrees, the pressure becomes 30 pounds per square inch near the apex on the same side and 27 pounds per square inch on the opposite side near the gingival line. This load may be in excess of normal physiologic limits which will result in a pathologic condition.

"Normal physiological limits" may alter from time to time depending upon the factors of age, nutrition, enzyme products of fungi, and so forth. Thus, the limits might be adequate at one time and inadequate at another time. It is in the latter stage that a breakdown occurs. The term "traumatogenic occlusion," originated by Box, indicates that occlusion may be a causative factor in the destruction of tissue.

It can thus be seen that anterior teeth with vertical overlap receive more lateral or oblique loading and are frequently in traumatogenic occlusion, while teeth with end-to-end occlusion receive axial loading, which is nearly always within physiologic limits.

Thus far we have discussed the subject in terms of anterior teeth. With posterior teeth the problem becomes more complex. If a tooth falls out of harmonious relationship and presents cusps that receive lateral loading, trauma often results. When this occurs, adjustments, either by grinding or by building up, are necessary. The object is to reconstruct the articulation so that not only will multiple contact of tooth surfaces in all positions be achieved and all

interferences eliminated, but cusps will be so designed that the resultant direction of the force will be in line with the long axis of the tooth and not laterally or obliquely.

RELATED STUDIES OF THE ARTICULATION OF ARTIFICIAL TEETH

There is no good reason to believe that the laws which indicate the differences between beneficial loading and traumatogenic loading will operate only on natural teeth and ignore artificial ones. It is true that we are dealing with denture bases rather than the roots of teeth, but that only makes the difference a mathematical one. The principle should be identical.

If lateral loading is objectionable in natural teeth, it should be just as objectionable in artificial teeth. It would seem that our objective should be to direct the forces in line with the vertical axis of the ridge so that the weight is borne equally by the entire surface of the ridge. This is difficult to compute because of the differences in angulation of each ridge and the differences of interridge relationship. The placement of the teeth presents problems both in tooth angulation and in ridge relationship.

Flat-cusped artificial teeth should traumatize the ridges less than cusped teeth because the direction of force tends to become axial. On the other hand, they are less efficient and, although they permit a longer glide, require more work, which may become a detrimental factor. With cusped teeth, shifting denture bases and altered hard and soft tissues under the denture bases due to function may cause alteration of the positions of these bases, and the finest interdigitation may thus become injurious. Your essayist now believes that when the hinge axis of opening movement is properly located and proper articulation is established (taking into consideration all the factors that are interrelated in good articulation, such as condylar inclination, incisal guidance, plane of orientation, and cusp height), very little alteration will take place because there are no interfering cusps in a good articulation. The upper and lower dentures slide about in all positions like two glass slabs, like flat-cusped teeth, but with all the advantages of sharp occlusal surfaces.

The use of flat-cusped teeth, however, is the lesser of the two evils if all these precautions are not taken in the articulation of teeth. Certainly teeth articulated on an instrument which does not locate the opening hinge axis, as does the McCollum gnathoscope, will tend to create an injurious relationship with every movement.

WHAT DO WE MEAN BY BALANCE?

The generally accepted method of today is to arrange teeth upon an adjustable articulator in such a manner that multiple contacts are made by the cusps in the various centric and eccentric positions. They are then said to be balanced. This is wrong. The eccentric positions are wrong because of the inaccuracy of the adjustable articulators. They are adjustable but not accurate. So far, I have seen only one instrument that appears to record mandibular movements accurately just as they are and, more important still, to register the opening hinge axis. Equivalent movements upon the average adjustable articulator

are not accurate. Only on such an instrument as I have mentioned may all the factors that are requisites of efficient articulation be utilized and incorporated in the building of artificial dentures, complete or partial. The mouth is not as good an articulator as a correct instrument. It is much better than an inaccurate articulator, but it cannot be easily controlled.

Your essayist had been using the mouth as an articulator for many years. Some of his experiments will be described with the mouth used as an articulator, but he has concluded that he was wrong and is very thankful to McCollum for making this important point clear to him.

Perfection has not yet been achieved, however. There are other factors to be considered.

In civilized man, the lower ridge is generally outside of the upper ridge. This produces a Monson pitch, particularly if one of the milling-in techniques is used (as we shall see later). The result would be a tendency to stabilize the upper denture and to dislodge the lower.

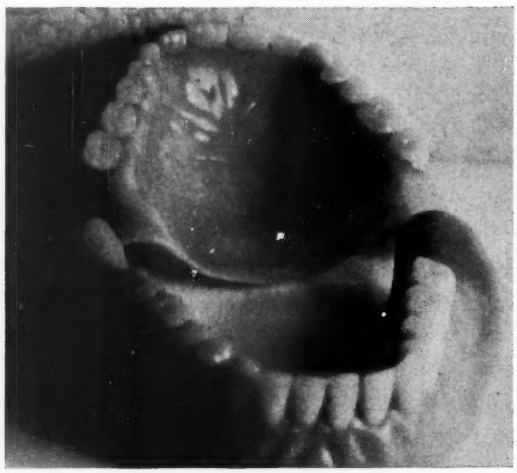

Fig. 14.—Upper and lower artificial dentures with anti-Monson pitch arrangement of teeth.

This is accomplished because the pressure on the lower teeth is converted to an outward direction toward the cheek. This outwardly directed force tends to dislodge the lower denture. We are generally more concerned with the lower denture; the upper denture rarely gives trouble from the standpoint of stability. Another way of illustrating the tendency to dislodge the lower denture by the application of force toward the cheek may be shown while the denture is in the patient's mouth. If the finger is placed upon the occlusal surfaces and pressure is applied laterally toward the cheek, the denture will dislodge. If the direction of force is toward the tongue, the denture will seat more securely.

For many years I have arranged teeth with an anti-Monson pitch (Fig. 14) "apparently" quite successfully. "Apparently" is used in quotations because there is no known method of comparing the degree of resorption of the ridges. One

thing appeared evident. There was greater stability of the denture during mastication than there was with the Monson type of setup.

Unknown to me, Pleasure had adopted an anti-Monson type of setup.[4] He employed an adjustable articulator. At the meeting of the American Full Denture Society in February, 1947, Dr. Luzerne Jordan of Washington showed a modification of the anti-Monson arrangement.

THEORY OF ANTI-MONSON PITCH ARRANGEMENT

Mastication is a unilateral operation. We eat on one side at a time. If this statement is true of the initial stages of mastication, is it not important to stabilize the lower denture? Wasn't it Prime who once said: "Enter bolus, exit balance"? There is no use talking about stability or balance with a bolus of hard resisting food in the mouth. If we arrange the teeth in an anti-Monson fashion, the direction of force will tend to stabilize the lower denture.

There is, of course, the danger that the pressure might be of an oblique character and might tend to destroy ridges. At present, your essayist is undecided whether destruction of the ridges is greater in the Monson type of setup or in the anti-Monson type. He has been equally successful in destroying ridges with both methods. We should place teeth so that the loading is axial or nearly axial in all positions, even during mastication.

As has already been mentioned, it is important to locate the axis or hinge upon which the mouth opens. Nearly all the anatomy textbooks claim that the hinge is located somewhere below the condyle. Some place it about the vicinity of the mandibular foramen. It is easy to see why this idea was conceived. The following illustrations are indicative of the general belief. The patient had the condyle exposed by an operation. Fig. 15 shows the condyle at rest position. The patient slides the mandible to the left, and the right condyle moves forward (Fig. 16). The patient opens the mouth, and the condyle also moves forward (Fig. 17). This actually takes place. Generally, when we open the mouth, the external pterygoid muscles act to poise the mandible in order to grasp. McCollum calls this a "prehensile movement."

We must not forget that these muscles are voluntary muscles. We may employ them to protrude the mandible or, if only one muscle is activated, to pull the mandible to one side. If it is a voluntary muscle, we should be able to leave it alone if we wish. It is more important, from a practical viewpoint, to ascertain whether the external pterygoid muscles are employed or not during the simple opening movement. Since they are attached to the condyles and the discs and since the only active thing that any muscle can do is to contract, the action of these particular muscles would be to pull the condyles forward. If they do this, the axis must be elsewhere.

For many years McCollum's voice has been a lone cry in the wilderness proclaiming that the axis or hinge of opening movement is in the condyle and is locatable. In spite of his repeated utterances and proofs, this has been ignored. A recent edition of an applied anatomy textbook (1947) still places the hinge axis in the vicinity of the mandibular foramen. This is very difficult to under-

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 15.—Rest position of condyle. (From Nichols.[5])

Fig. 16.—Patient slides mandible to the left. Condyle is forward. (From Nichols.[5])

Fig. 17.—Opening movement. Condyle is also forward, but pathway is different since the movement is induced by muscles of both sides, unlike the movement in Fig. 16 where muscles on one side only are utilized in lateral motion. The pathway in Fig. 16 tends to become an arc while that in Fig. 17 becomes more of a straight line. (From Nichols.[5])

stand. Surely it is of sufficient importance to all of dentistry to have the subject investigated.

For example, if when milling-in a denture, which incidentally is very poor practice, the hinge is not located in the correct position, every successive alteration by grinding increases the error. Again, if it is desired to increase the vertical dimension in cases where it has been closed, and if we estimate the new opened position on the basis that the condyle moves forward on opening and articulate teeth on that assumption, how disastrous it would be to the articulation if the condyle resumed its original position. Or again, when registering centric occlusion do we always obtain exactly the same vertical dimension? A fraction of millimeter of error, when using cusped teeth on the average articulator, could be disastrous. It was with this in mind that your essayist decided to perform some simple experiments to bring to the attention of the profession the fact that the condyle need not be brought forward when the mouth is opened. An edentulous patient was procured, baseplates were adapted, and an intraoral Gothic arch tracer was fastened with compound. Although it has been proved that the Gothic arch tracing is not absolutely accurate, it was accurate enough for this experiment, the purpose of which was only to prove that there was no perceptible forward movement. Since the condyles are in their most retruded position at centric position and since the apex of the Gothic arch indicated centric or nearly centric position, a tracing was made at each of three levels. The apex of each Gothic arch indicated centric position at each level. A tracing was made at closed, medium, and wide open levels. Of course, each apex formed posterior to the last one as the mouth was progressively opened wider. Dr. Worth, of the Faculty of Dentistry, took temporomandibular roentgenograms at one of the Toronto hospitals for me. This made it necessary to proceed as follows: A Gothic arch tracing was made with the mouth in a closed vertical dimension position. The patient was instructed to lie down in order to have a roentgenogram of the condyle made. Next, a new tracing was made with the patient sitting up and with the mouth opened half wide. The patient was instructed to lie down again for a new roentgenogram. The procedure was again repeated with the mouth opened very wide.

Under the circumstances, accuracy in angulation could not be obtained. Nevertheless, the roentgenograms showed that the condyles were in almost the same relative position at each level.

Thus we can see the importance of locating the hinge axis. It has a tremendous bearing on the performance of correct restorative dentistry.

THE SHAPE OF THE CONDYLE

Does function form the shapes of the condyles and fossae and alter their paths, or do these shapes remain constant after their formation? The evidence seems to point to the versatility of bone. Bone alters to meet new work, new pressures, and new environment. Breitner[6] performed experiments upon monkeys by altering their occlusions with orthodontic appliances. He found that the bone of the condyles resorbed in some places and formed new depositions in others as the function altered.

It seems obvious that by the laws that govern the economy of function, alterations will take place with each change of function. In dentitions that have steep vertical overlaps which permit very little protrusive movement, the habitual masticatory stroke is an opening and closing movement with some lateral motion. If the lateral movement is also limited, it is very similar to the hinge action employed by the Carnivora. The condyles of a carnivorous animal, because of that type of action, are rounded and steep. It is often difficult to separate the mandible from the rest of the skull of the Carnivora, because of the form which nature gives to this joint in keeping with the straight up-and-down movement. This is evident in the formation of the joint in the giant panda (Fig. 18). Even herbivorous animals, which are browsers, have steeper and rounder condyles than grazing animals, which have flatter condyles. This is so because they have to chop off leaves by employing a hinge action as well as a lateral one.

Fig. 18.—This mandible of the giant panda could not be separated from the maxilla. Carnivora, having a pure hinge motion, often have the margins of the fossa form around the condyle.

Human beings, having very little lateral or protrusive motion, will develop steeper condyle paths similar in form to the Carnivora because the action is similar. Function begets form to a large extent.

This does not mean that a pattern of motion will not be influenced by the form. On the contrary, movements are influenced by the shapes of the bones involved which, in turn, were thus formed by the functional factors in the individual. If this form is adhered to and teeth are properly articulated in conformity with this form, there is no reason to believe that there will be further alteration. This is probably the reason that the McCollum group subscribes to the belief that form does not alter.

When does form stop altering? Alterations certainly take place during growth. Examination of old edentulous skulls reveals that the condyles are

smaller. Would not the diminished blood supply and all other factors of old age be a cause? Would not lessened function which atrophies all other bones also alter the bones of the condyles and fossae? Or are these bones the only ones in the body which are immune?

What leads this group astray is the fact that the opening hinge axis remains constant even if articulations which were in an eccentric position are corrected. They believe that since the mandible will resume its normal position in the fossae upon correction of the condition, the shape of the condyles and fossa did not alter.

This reasoning I believe is erroneous because at rest position the teeth do not occlude, and the mandible is in its customary position from which all movements begin. Since an opening movement does not cause any teeth to meet, their altered positions will have no effect upon this opening movement. Only closing the teeth will affect the bony tissues of the condyle and fossa. Therefore, there is little reason to believe that the hinge axis should not remain constant after maturity. It might change slightly if general atrophy takes place, and it might not. This would not have any bearing on the condyle path which is influenced by function.

EXPERIMENTS TO CONFIRM STUDIES OF PITCH

We have seen that the pitch of the teeth varies with interridge relationship. As a general rule, if the upper and lower ridges are directly over one another, we expect that the pitch of the occlusal surfaces of the opposing artificial posterior teeth should be horizontal because the natural teeth of both human beings and animals would be horizontal. If the lower ridge is situated outside of the position of the upper ridge, making the lines intersect above the upper ridge, the pitch should be Monson-like.

Experiment A: An attempt was made to produce this condition artifically. Upper and lower casts were mounted on an adjustable articulator. No great care was taken to mount them, except that the upper cast, which was smaller, was placed in such a relationship that the lower arch was wider than the upper in all positions. No attention was paid to condylar guidance. Baseplates were adapted to the casts, and a soft plastic wax was piled rather high on the ridges of both casts. The wax was covered with tin foil which was lubricated. The tin-foil-covered wax on the upper cast was rubbed against that on the lower cast in all directions in a manner similar to the milling-in methods advocated with some techniques. A Monson pitch was formed (Fig. 19).

Experiment B: A very large upper cast was mounted over a small lower cast. The same procedure was carried out as in Experiment A. The result was an anti-Monson pitch (Fig. 20).

History of the Various Milling-in Methods.—Milling-in is performed in many ways. Very often dentures are remounted on articulators, carborundum paste is spread over the teeth, and the upper denture is rubbed against the lower. Occlusal paths are thus established and interferences removed. As has already been pointed out, this is a very destructive process.

Milling-in was performed as early as the turn of the century by Christensen. He did it both in the mouth and on an articulator. Paterson standardized it and incorporated it into a definite denture technique. After the compound occlusion rims were made on the mounted articulator, troughs were cut out on the occlusal surfaces of the compound. A mixture of plaster and carborundum was placed in the trough and over it. When this hardened, the baseplates were introduced into the patient's mouth where they were milled in. An occlusal path or surface was thus formed on both rims, and this was believed to be the patient's own path, as a result of the condylar movement. Teeth were set to this surface.

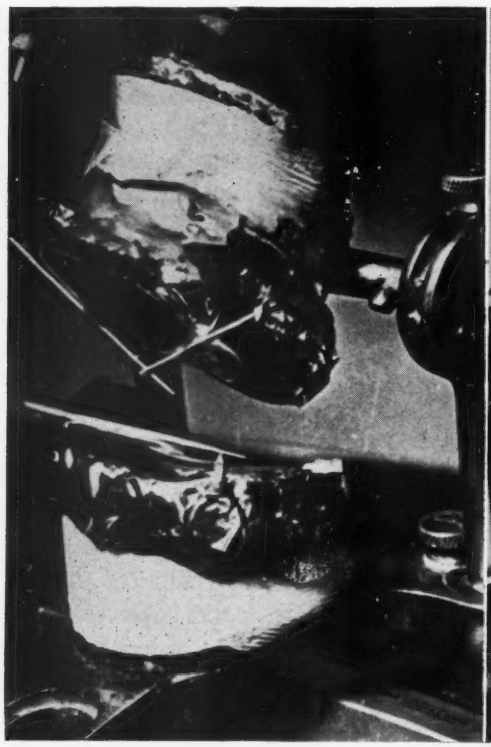

Fig. 19.

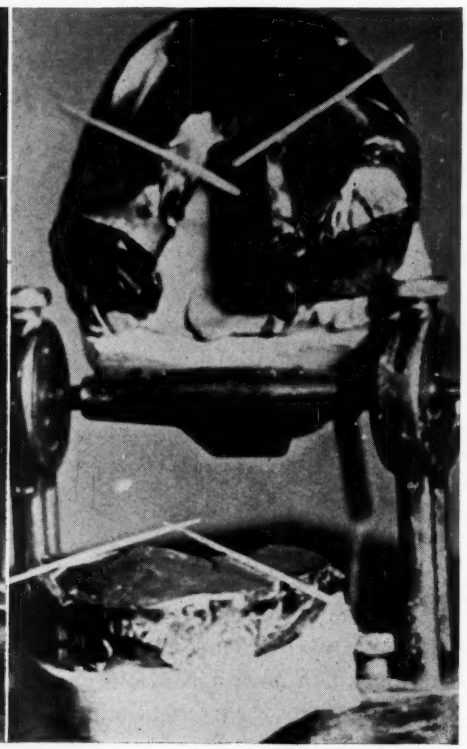

Fig. 20.

Fig. 19.—Monson pitch is created by rubbing together lubricated surfaces of tin foil over soft wax, the mandible being wider than the maxilla. This method parallels some of the current milling-in techniques.

Fig. 20.—Anti-Monson pitch is created by rubbing together lubricated surfaces as in Fig 19. This time the maxillary cast is larger than the mandibular.

Wadsworth included Paterson's milling-in technique as a desirable addition to his own method of articulation, which he performed upon an articulator of his own design. Hall also used a milling-in technique at one time. Of late, the popular milling-in technique is the one devised by Meyer. Meyer employs wax instead of plaster and carborundum when milling-in the baseplates in the mouth. An occlusal path is formed on the soft wax occlusal surfaces of the compound rims. Teeth are set to this path, and the "balanced" occlusion thus obtained is

said to be compatible with the tissues, to be an accurate product of condylar movement, and to stabilize the denture bases.

Jaffe altered the method somewhat by finishing one of the dentures before milling-in. The writer has used this method a great deal. It seemed to lend itself to the idea of setting up the upper teeth first for esthetics and then of stabilizing the lower denture by arranging the posterior teeth in an anti-Monson fashion.

Fig. 21

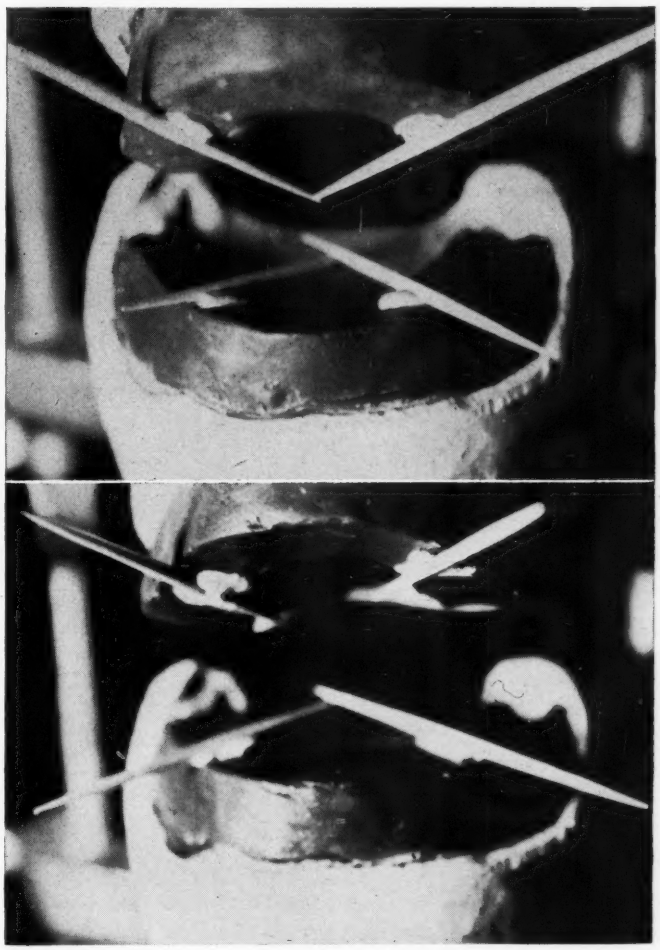

Fig. 22.

Fig. 21.—The lower occlusion rim was carved into a Monson pitch, and the softened upper rim was rubbed against the hardened lubricated compound of the lower rim. The result was a Monson pitch in the upper rim. This method is similar in principle to that used in the Jaffe method.

Fig. 22.—An Anti-Monson pitch was carved on the lower rim, and the experiment was repeated as in Fig. 21. The result was an anti-Monson pitch on the upper occlusion rim.

Predetermined Milled-in Paths.—Using the same patient and at the same sitting, experiments were performed to determine whether both a Monson and an anti-Monson pitch could be made in the same mouth.

Experiment C: After the occlusion rims were built on bases upon casts which had been mounted on an articulator in the orthodox manner, the lower occlusion rim was carved, arbitrarily, into a Monson pitch; a few millimeters of compound were added to the upper occlusion rim. This was softened by passing a flame lightly on the surface, tempered in water, and inserted into the mouth along with

Fig. 23.

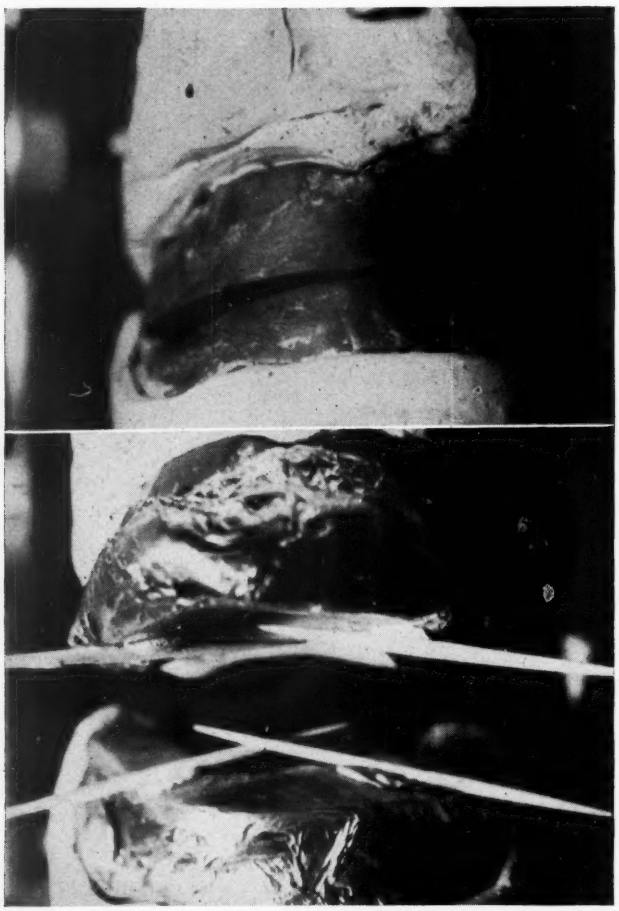

Fig. 24.

Fig. 23.—The upper compound occlusion rim was deliberately made larger than the lower rim. The rims were then covered with soft wax on which was placed tin foil which was lubricated. This was milled in the patient's mouth.

Fig. 24.—Anti-Monson pitch deliberately created in the patient's mouth by the milling-in technique.

the chilled and lubricated lower occlusion rim. The patient was instructed to rub the rims together in all positions. A Monson pitch was formed on the upper occlusion rim (Fig. 21). There appeared to be multiple contacts of the compound rims during all movements of the mandible. This is not absolutely true because the bases shift. It is another reason why the mouth is not a good articulator.

Experiment D: The experiment was repeated, but this time an anti-Monson pitch was first carved on the lower compound rim. The upper rim became anti-Monson in form and appeared to make multiple contact in all positions (Fig. 22).

Thus, it seems that teeth may be arranged in a predetermined manner and have stability. Correct articulation, however, is a different story and will have to be carefully investigated.

Fig. 25.

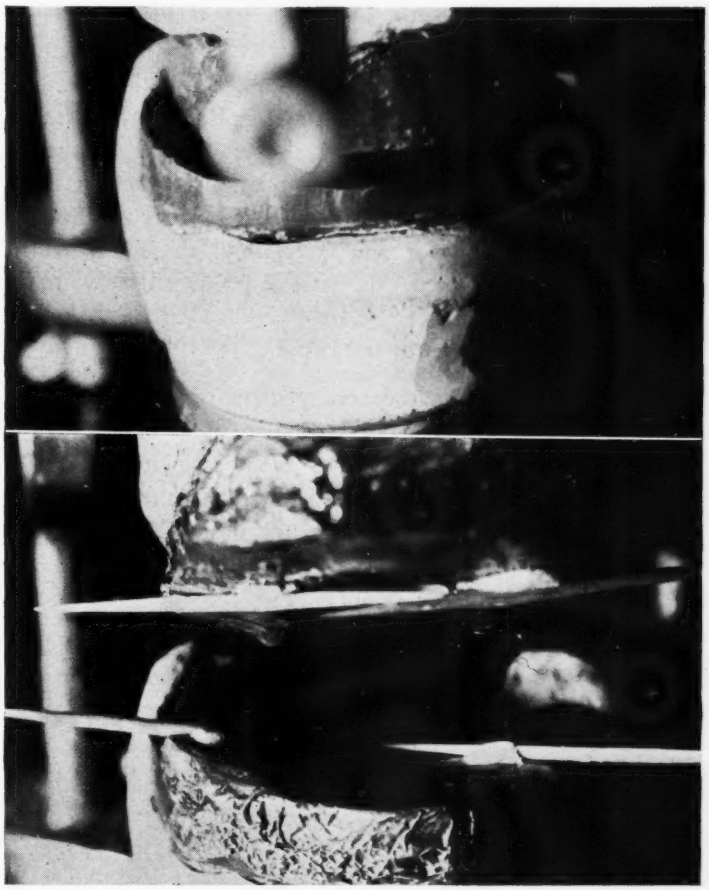

Fig. 26.

Fig. 25.—The lower occlusion rim is made wider than the upper one.
Fig. 26.—The Monson pitch after being milled in the patient's mouth.

Are Milled-in Paths Constant?—The aforementioned experiments suggested that perhaps the occlusal paths in some of the milling-in techniques are not always constant. If, by altering the relationship of the rims, changes in patterns could be made, it would indicate that the path is not influenced wholly by condylar guidance.

Experiment E: Well-constructed compound occlusion rims were again placed on well-adapted baseplates. The upper compound occlusion rim was formed so that its outer circumference was greater than that of the lower rim (Fig. 23). About 3 mm. of the compound on the occlusal surface of each rim were shaved off. About 4 or 5 mm. of soft plastic wax were placed on each rim; the wax was covered with tin foil which was lubricated. The baseplates were inserted into the mouth, and the patient was asked to mill this in. The result was an anti-Monson pitch (Fig. 24).

This experiment was, of course, exaggerated. It proves, though, that the pattern of the occlusal path is influenced by the relationship of the rims.

Experiment F: The experiment was repeated. This time the lower rim was made wider than the upper (Fig. 25). A Monson pitch was the result (Fig. 26). This was also exaggerated because the rims do not project to such a degree in the Meyer or in other techniques. There is a relationship between the upper and lower occlusion rims that can vary. With each variation, a different pattern of the occlusal path will likely be formed. Certainly, these experiments indicate that the pitch may be predetermined. If what is produced is the natural occlusal path, which one shall we use?

SUMMARY

There are laws which govern the arrangement of the natural teeth. These laws are found to be constant in the teeth of animals as well as human beings.

The inclination of the natural posterior teeth is governed by different factors from those which govern the pitch of the occlusal surfaces. The pattern of wear has a strong influence upon the pitch of the occlusal surfaces.

Wear could be of a beneficial, physiologic nature up to a point.

Function is an important factor of form.

CONCLUSIONS

The subjects which have been discussed in this essay have not been completely dealt with. A great deal more work will have to be done on each phase. Sincere objective investigations will have to be made. All the laws that manifest themselves should be canvassed completely, and new laws should be established. The biologic approach should supersede the mechanical approach of the past.

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45 Avenue Road
Toronto, Ontario, Canada

SPECIFICATIONS FOR ARTIFICIAL POSTERIOR TEETH

VICTOR H. SEARS, D.D.S.

Salt Lake City, Utah

AFTER more than one-quarter century of experience with artificial posterior teeth designed especially to meet the requirements of the edentulous situation,[1] now, if ever, we should be able to formulate a rational set of specifications.

That the edentulous situation does require forms different from the anatomic ones of nature should be clear by now. Although this newer concept has not yet been universally accepted, its ultimate acceptance is well assured.

There have been described at least ten essential mechanical differences between natural and artificial dentures.[2] No competent engineer would think of designing two identical bridges, to take an example, where two situations contain so many essential differences. He would specify different forms to meet different circumstances. The dentist should do no less. Both should try to take into account all of the factors and work out the requirements for meeting each situation.

The setting up of specifications is a valuable and well-accepted device for making sure that the parts will be satisfactory in relation to the whole and that the whole will serve the purpose for which it is designed. In design and composition each part is likely to be more appropriate if its description is set down clearly in words and/or other suitable symbols.

Specifications need to be based on a grasp of the function in a given situation, whether the subject be a bridge, a dam, a building, or a set of artificial dentures. Suitable specifications contribute to the success of any such undertaking.

Certain principles govern any rational concepts in the matter of posterior teeth and there can hardly be any serious disagreement on these principles.

Different tooth designers will draw up somewhat different specifications. Though different, they will be appropriate to the extent that they conform to the principles involved.

It is not contended, nor even believed, that there is anything final about the specifications here given. It is, however, stoutly maintained that some occlusal forms are more appropriate than others. It should also be clear that logical specifications will help to rate forms already available and to devise better ones. With these premises in mind the author will list, at the end of this article, the seventeen major specifications for artificial posterior teeth as he has evolved them to date.

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BACKGROUND MATERIAL

So far as is known, the first occlusal surfaces designed especially according to the mechanical requirements and with avowed disregard for anatomic patterns were those designed by the writer. They were first exhibited before the National Society of Denture Prosthetists in 1922.[3] Two years later Campbell showed illustrations of them in his textbook.[4]

At first the specifications were rather general. Perhaps the most important and most definite one was that the forms should be such as to "minimize interference in protrusion." This was accomplished by eliminating all cusp inclines as seen from the buccal side. As for the other cusp inclines, no definite specification was set up. This matter was left undecided in the paper with the suggestion that: "Further experimenting in the mouths of our patients will show what steepness, if any, the upper buccal inclines should have."[3]

After more than thirty years of designing and testing various nonanatomic forms, the writer still has come to no final conclusion as to the inclination of the upper buccal cusp. It may be that there is some acceptable inclination for all cases; it may be governed partly by the steepness of the condyle path; it may be that a mesiodistal sulcus should be more or less cylindrical. For the past several years the writer has been using working occlusal surfaces that are essentially horizontal.

By 1927, in a paper read before the American Dental Association,[5] the absence of "any boxlike cavities which might entrap small masses of food" was stressed, and in the matter of buccal cusp inclines it was more definitely suggested that they should be "relatively low."

Following this paper, there were many discussions among denture workers about the advisability of departing from human anatomic patterns and in what particulars the departure would be beneficial. However, it was not until 1931 that ten definite specifications were formulated.[6] In 1935 this number was increased to fourteen.[7]

As the leaders in the prosthetic field gained experience with nonanatomic forms, there was less and less insistence by the tooth carvers that artificial posterior teeth should copy natural forms exactly.

There followed many offerings of forms that were described (wrongly) as "natural" but that embodied certain "improvements." Without conceding their nonanatomic features, the sponsors claimed they were anatomic forms merely "modified". Apparently, for psychologic reasons, some of the offerings were presented as anatomic forms in spite of the fact that no anatomist would agree. To the extent that the designers hugged this delusion it was to that extent that their carvings failed to take full advantage of the mechanical possibilities. Several highly qualified prosthetic workers would start with so-called anatomic teeth and grind their occlusal surfaces beyond recognition, ending up with nonanatomic forms. Thus they arrived the hard way at nonanatomic occlusion, while declaring themselves users of anatomic forms. Fortunately this emotional block is giving way under the impact of practical experience. The designation "nonanatomic" is not entirely satisfactory, but no better term occurs at present. As used here, it means teeth designed on a mechanical rather than anatomic basis.

It would seem a logical approach to design the posterior teeth so as to obtain the greatest possible mechanical advantages with regard to the situation at hand and without regard to forms found in a previous situation. After this start, the designer can make such modifications toward the anatomic forms that will not too greatly nullify the strictly mechanical advantages.

Before listing the specifications themselves, two comments should be made, one on efficiency and one on wear resistance.

Although chewing efficiency has been implicit from the beginning, there is now and then a tendency to overemphasize this requirement. It will be noted that the patient tends to chew his food to the same fluidity, or at least to the same degree of comfort in swallowing, almost without regard to the number of strokes required. Chewing efficiency should not be judged entirely on the number of strokes used. Edentulous dentists in making tests in their own mouths discover no great difference in the efficiency of acceptable forms when considering all foods.[8]

On the matter of wear resistance, the advent of plastic teeth has brought into prominence the question of the degree of wear desired, but for the most part the disscussions have concerned themselves with entire sets of identical composition. It seems a bit strange that only recently have we considered the advantages of making some teeth of the set more resistant to wear than others.[9]

The 1952 specifications here appended are grouped without reference to the order in which they were announced. Nor are they listed in order of their importance. Rather they represent the writer's present convictions grouped into more or less logical divisions according to the functions of the several parts.

SPECIFICATIONS*

Working Occlusal Surfaces

1. The working occlusal surfaces should be void of cusps or inclined planes that might hinder the free horizontal gliding of opposing surfaces as the alveolar ridges resorb or as the mandible carries the teeth into protrusive occlusion (Fig. 1).

2. The working occlusal surfaces should have no inclined planes (or only low ones) that might hinder the free horizontal gliding of opposing surfaces as the mandible carries the teeth laterally (Fig. 2).

3. The working occlusal surfaces should be so incorporated that more than 50 per cent of such surfaces can be placed lingual to the ridge center, with 100 per cent as the ideal (Fig. 3).

4. The working occlusal surfaces should be so incorporated that the greatest load can be applied at a desired mesiodistal point. This provides against front-to-back teetering (Fig. 4).

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*The illustrations are intended to further clarify the specifications listed and to indicate the principles dictating the specifications. There is a certain degree of exaggeration introduced into some of these schematic drawings for the purpose of making clear the application of principles.

In the illustrations, *W* and *B* stand for working and balancing occlusal surfaces, respectively. Thus "1W" stands for Specification 1 under the heading, Working Occlusal Surfaces.

5. The working occlusal surfaces should be so incorporated that they can be placed parallel with the underlying alveolar ridge as seen from the side (Fig. 4).

6. The area of the combined working occlusal surfaces should be in proportion to the supporting value of the weaker of the two denture foundations. Weaker foundations require smaller occlusal surfaces. This would not require a large number of molds if Specification 7 is met.

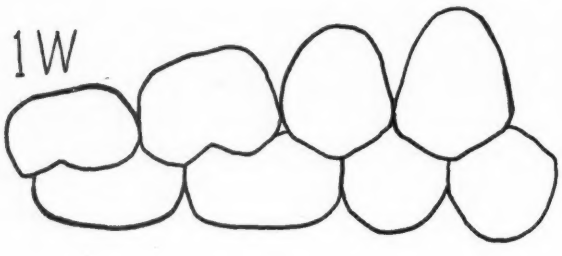

Fig. 1.

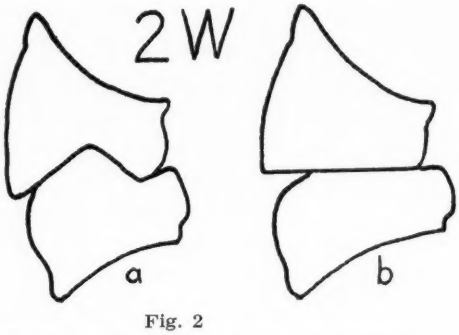

Fig. 2

Fig. 1.—*1W*, Right view of anatomic arrangement of cusps. This kind of occlusion prevents the straight protrusive movement of the mandible without a forward thrust on the upper denture and a backward thrust on the lower one.

Whenever in protrusive occlusion the mandible exerts vertical force on cusp inclines, there develops an undesirable horizontal thrust on the denture bases. This occurs under the temporary protrusion of the lower teeth on both sides in straight protrusion, on the balancing side in lateral occlusion, and on both sides in permanent protrusion due to wear of the teeth or resorption of the denture foundations.

Fig. 2.—*2W*, Mesial view of right first molars. *a*, Characteristic cusp arrangement of anatomic teeth. *b*, The lateral clearance afforded by cuspless teeth.

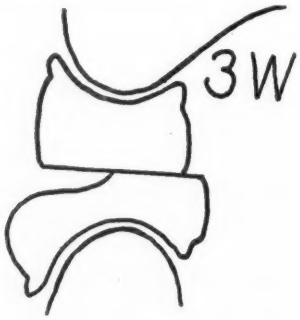

Fig. 3.

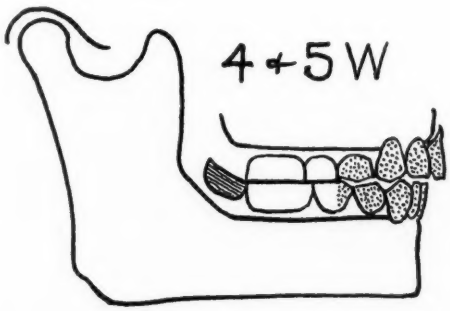

Fig. 4.

Fig. 3.—*3W*, Mesial view of right first molars. This shows one way of placing the load to the lingual side of the lower ridge center.

Fig. 4.—Right view of an arrangement that meets Specifications 4 and 5, Working Occlusal Surfaces. *4W*, Only the upper second bicuspid and first molar occlude with the lower teeth in centric occlusion, thus placing the load at about the front-to-back center. *5W*, Here the working occlusal surfaces lie parallel with the denture foundations, thus preventing any horizontal thrust due tc inclined plane action.

Dotted teeth carry subocclusal surfaces and the lined second molar is only for protrusive balance.

7. The teeth should be so designed that they can be altered by grinding without losing their mechanical or esthetic advantages. This has special reference to the possibility of reducing, either buccolingually or mesiodistally, teeth that may be slightly too large.

8. There should be no wells, traps, boxlike cavities, or hollows into which food can pack. All major depressions should be provided with adequate escapeways (Fig. 5).

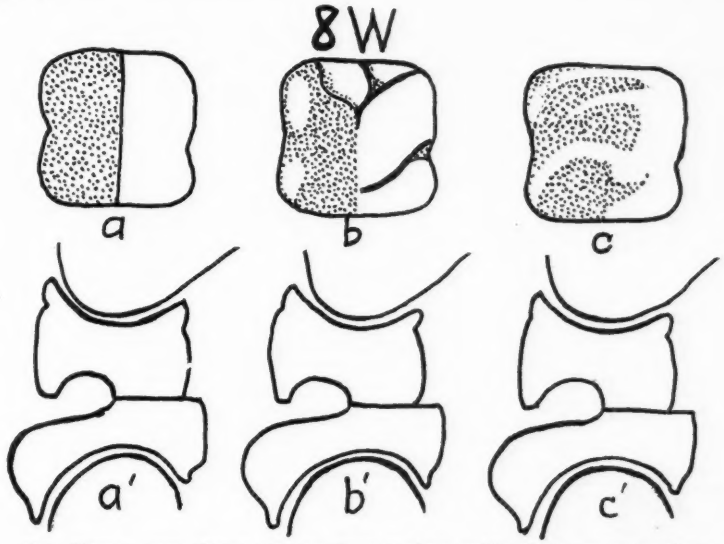

Fig. 5.—*8W*, Upper row shows upper first molars with their mesial edges toward the top; lower row shows mesial view of cross sections at the distal ends of the same teeth as they appear in occlusion with the lower molars. Dotted portions indicate subocclusal surfaces.

a, Simple division of the working occlusal and subocclusal halves. This unbroken working occlusal surface is not so efficient as one with escapeways.

b, The working occlusal surface is cut with escapeways; there are two small areas on the buccal half to aid in arranging the teeth in wax.

c, The escapeways are of a different pattern from those in *a* and *b*, but in all three instances Specification *3W* is observed.

As shown in the lower three figures, the load remains on the tooth surfaces lying to the lingual side of the ridge center.

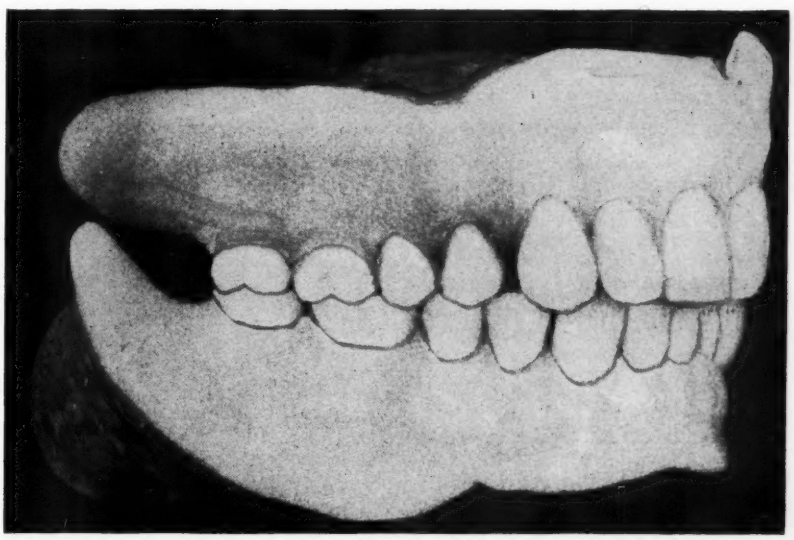

Fig. 6.—*9W*, When the posterior teeth are locked together with cusps, it is sometimes necessary to compromise esthetics as shown here.

9. The working occlusal surfaces should be so formed that there will be no necessity to leave spaces distal to the upper cuspids, or to narrow the lower eight anterior teeth as is done with the so-called anatomic teeth, where less-than-average horizontal overlap is used. This requirement is met essentially by observing Specification 1 (Fig. 6).

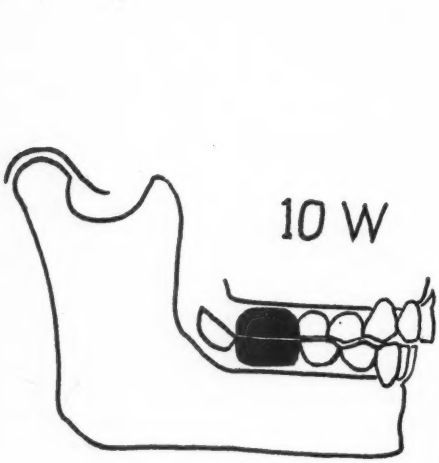

Fig. 7.

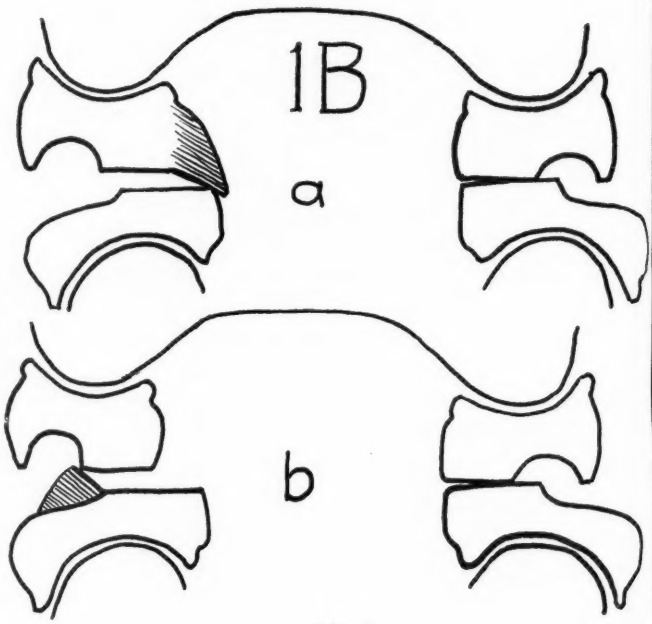

Fig. 8.

Fig. 7.—*10W,* If the first molars are composed of some highly wear-resistant material such as porcelain and the teeth anterior to those are less wear resistant, the great wear of the latter will tend to maintain the load in the molar regions.

Fig. 8.—*1B,* Molars of the right side as seen from the front, with the teeth in left lateral occlusion.

a, The balancing surface is carried on the lingual side of the upper first molar.

b, The balancing surface is carried on the buccal half of the lower second molar. The advantage of this over *a* is that the balancing unit is out of the way of the tongue. This placement, as in *b,* is possible only when the buccal portion of the upper first molar is cupped out sufficiently.

The darkened balancing cusp shown at *b* lies distally to the first molars and therefore does not come into function on the working side.

10. Those parts of the occlusal surfaces on which it is desired to maintain the principal load (usually the first molars) should be composed of a more wear-resistant material than the other parts. This tends to assure automatic occlusal adjustment under changes due to ridge resorption and condyle migration[10] (Fig. 7).

Balancing Occlusal Surfaces

1. Balancing occlusal surfaces should be so incorporated that they can be made to maintain contact on the right and left sides as the mandible carries the teeth into left and right lateral occlusions. Such lateral balancing occlusal surfaces can be placed conveniently on the upper first molars or the lower second molars (Fig. 8).

2. The balancing occlusal surfaces should be used only for balancing. This means that these surfaces should not be used also for working occlusal surfaces as is the case with so-called anatomic teeth.

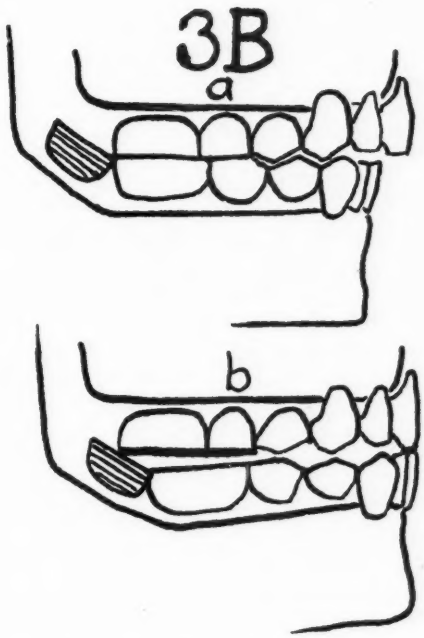

Fig. 9.—*3B*, Teeth viewed from the right side.
a, Centric occlusion; *b*, protrusive occlusion. The lower second molar maintains contact with the upper first molar.

3. Right and left balancing occlusal surfaces should be so incorporated that they can be made to maintain contact simultaneously on the right and left sides as the mandible carries the teeth into protrusive occlusion (Fig. 9).

4. All balancing occlusal surfaces should be adjustable independently of the buccal, lingual, working, and subocclusal surfaces. This is in contrast to the so-called anatomic scheme in which balance is obtained by tilting the entire tooth and thus disturbing the angles of the other surfaces (Fig. 10).

5. Each balancing occlusal surface should be adjustable independently of all other balancing occlusal surfaces. This requires a minimum of four units: (1) right for left lateral, (2) left for right lateral, (3) right and (4) left for protrusive occlusions (Fig. 11).

Buccal and Lingual Surfaces

1. The buccal surfaces should be so incorporated that they make satisfactory contact with the cheeks without contributing to cheek biting.
2. The visible buccal surfaces should simulate the forms of natural teeth.
3. The lingual surfaces should be so incorporated that they make satisfactory contact with the tongue in eating and speaking without contributing to tongue biting.

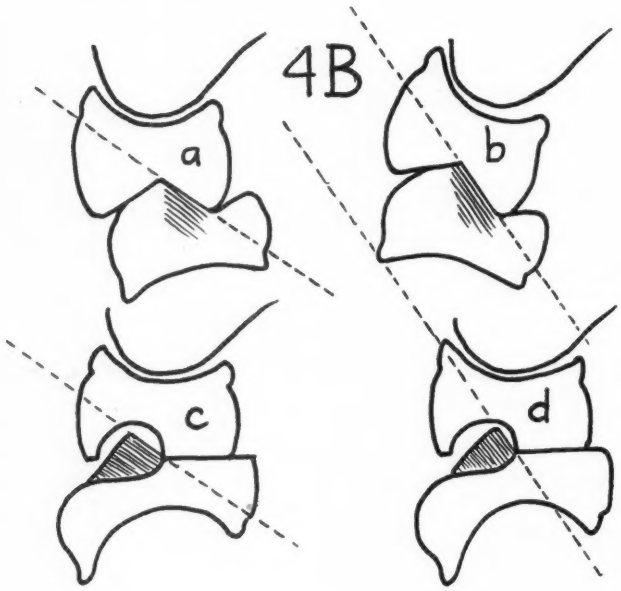

Fig. 10.

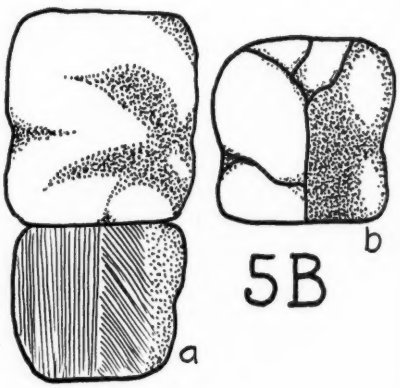

Fig. 11.

Fig. 10.—*4B,* Molars of the right side as seen from the front.

a, The buccolingual inclination of cusped teeth when the left condyle path is not steep.

b, The same teeth as in *a* with steep left condyle path. This throws the buccal cusps at awkward angles.

c and *d,* The buccal surfaces and the working occlusal surfaces remain undisturbed even though there has been a change in the left condyle path. To maintain the buccal and working occlusal surfaces in their best inclinations regardless of steepness of condyle path, the steepness of the balancing occlusal surface is reduced by grinding or milling as the steepness of the condyle path is reduced.

The darkened balancing cusps shown in *c* and *d* lie distal to the first molars and therefore come into function on the balancing side but not on the working side.

Fig. 11—*5B,* The right first and second molars as seen from above (*a*). In centric relation the upper first molar should be centered from right to left with the lower one, and occluded anteroposteriorly so that its distal edges of the upper and lower first molars coincide. In this arrangement, a straight protrusion brings the protrusive balancing surface carried by the lingual half of the lower second molar into function; left lateral movement brings the lateral balancing surface carried by the buccal half of the lower second molar into function.

b, The occlusal surface of the upper right first molar as seen from above. To see how the occluding surfaces of the first molars fit together, imagine *b* to represent a transparent tooth moved over onto *a*.

In practice, the protrusive balancing surface of the lower second molar articulating with the lingual half of the distal edge of the upper first molar is given the required inclination for protrusive balance at the try-in stage. Lateral balance is ignored at this time. After processing, the inclination of the lateral balancing unit of the lower second molar is reduced to meet the requirement of lateral balance.

Subocclusal Surfaces

1. Subocclusal surfaces should be so incorporated that they make no contact either as working or balancing occlusal units.

2. Subocclusal surfaces should, for esthetic reasons, carry carvings to make the teeth appear similar to natural forms.

SUMMARY

It will be seen that the so-called anatomic or cusped teeth, as well as most of the nonanatomic teeth, fail to meet a number of the requirements here listed. This set of specifications can be used to check the suitability of any type of posterior tooth or to evolve others. With this framework there is considerable latitude of design. It is worth stressing that the principles are of prime importance; actual design is secondary.

Doubtless other specifications will be added. So long as these are in harmony with the basic principles, we can expect future designs to become more and more appropriate.

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1007 Tribune Telegram Bldg.,
Salt Lake City 1, Utah

THE SCOTT SYSTEM OF PRECISION ARTICULATION IN THREE-DIMENSIONAL OCCLUSION

J. E. Scott, D.D.S.

Pratt, Kansas

THE Scott system of precision articulation in full denture construction is a radical departure, in principle, from previous methods used by prosthetists. Its aim is to correlate the anatomic movement in the temporomandibular joint, during anteroposterior and lateral excursions, with the mechanics of the articulator.

The theory is based on the laws of compensatory leverage. The condyle heads are the media for obtaining the incidence of angulation in the mandibular drop during the protrusive and retrusive and lateral motions utilized in the chewing act. No interference is encountered in the free-way space at any time. With the maxilla and mandible in the centric position, the teeth occlude perfectly. Here, the laws of mechanical force and anatomic leverage coincide, for the theory takes into consideration the four basic principles inherent in the laws of machines. A graphic comparsion of the end results in the construction process is the development of a veritable masticatory grinding machine.

The theory of compensatory leverage is most clearly demonstrated in the lateral and rotary movements of the mandible in cases of extreme prognathism and retrusion. Effort has been concentrated on synchronization of the condylar movement, in the dynamics of mastication, to obtain equal bearing stress on all points of contact, both in and out of centric relation, and to assure equilibrium of the mandible in the physiologic rest position.

ATTEMPTS TO ESTABLISH BASIC CONCEPTS

A search of the dental literature indicates that much study has been made in the field of prosthetics in an effort to solve the most combative problems associated with perfect fitting and retention of dentures.

In examining the various techniques, there is little or no variance in the initial preparation for making full dentures. Each case reported illustrates wide usage of the roentgenogram in the exploratory and diagnostic phases.

Considerable insight has been manifested regarding the complicated structure of the masticatory apparatus, including the character of the soft tissues, the alveolus, and the bony arch on which the dentures are to be properly balanced.

Robinson[1] has stated that, among the many concepts in denture construction which have been accepted by the profession, the concept of the centric position

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stands out as the vaguest and most ambiguous—certainly one of the most important. He states: "Most definitions are based on clinical observations with consequent interpretations of the actual situations. If one is to define centric relation, it must be done anatomically since it is basically an anatomic study."

Thompson,[2] who has made a study from the anatomic approach, refers to the centric position as one which cannot be described in a few words. Equally true is an attempt to explain the equilibrium of the condyle path. In his attempt to define centric position he states that it is not only the maxillomandibular relation where the teeth occlude in the normal or good functioning situation but also where the condyle of the mandible is in a balanced and unstrained position in the mandibular fossa. He has made quite an extensive study on the significance of the physiologic rest position of the mandible and its influence on prosthetic restorations.

Besides theorizing, many technical studies have been made to ascertain the exact relationship of the condyle path and synchronization of the maxillary and mandibular contacts. Boos[3] has presented some interesting data on the intraoral and extraoral investments in his attempt to describe the problems involved in attaining perfect occlusion. He indicates the importance of understanding the movements of the condyle in securing perfect balance and maximum retention.

MALOCCLUSION AND ADHESIVES

Apparently, the problem of retention has been greater than the average reader of dental literature would assume. McKevitt[4] mentions the extensive use of adhesives in his discussion of the large variety available on the market and states that the powder users are grouped into three classes:

"1. Those who because of the peculiar shape of their mouths are unable to obtain dentures which afford much suction.

"2. Nervous patients requiring additional assurance of complete comfort.

"3. Those who cannot afford an accidental slip of their dentures, such as attorneys, actors, public speakers, etc."

In this connection he pointed out there were 15,000,000 denture wearers in the United States in 1939. We have reason to believe that the number is much larger now.

Thompson,[2] in his discussion of the centric position and malocclusion, places the fault of abnormal functional problems on lack of proper vertical dimension. From an examination of the techniques used in obtaining the vertical dimension, there is little wonder that variances may arise. There has been no indication that any attempt has been made to establish this dimension on the basis of a bone tissue measurement.

Nor is the problem of malocclusion confined to discussion of its effect on the oral structure. Recent reports from otolaryngologists show cases of partial and complete deafness on the increase. Some studies in dental literature indicate a possible cause of deafness as resulting from retrusion of the condyle head on the auditory meatus. Pryor[5] has given an interesting account of faulty occlusion

in one of our eminent historical characters, George Washington. This is a situation which, as a matter of caution, is being brought more and more to the attention of dentists.

STANDARDIZING TECHNIQUE FOR COLLEGES

Nowhere in the literature has there been a discussion on the practice of occluding the maxilla and mandible according to the anatomic laws of the human jaw, wherein the maxilla remains stationary while the mandible performs the motions which produce mastication.

McKevitt[4] admits that at the present time full denture prosthesis is not at its highest standard. He states: " . . . it may be feasible to work out a simple system of standardized technique that will be acceptable to colleges—a system that will yield results beyond present-day accomplishments."

In so stating, McKevitt has inferred that, in order to offer a technique to the colleges for establishment of a recognized system, it must be a simple system. This implies a recognition of a need to understand the related laws in the science of physics, since it involves a study of properties, bodies, and motion. Otherwise, it would be impossible to refer to the problem of condylar synchronization, or maxillomandibular occlusion, as a matter that could be solved by a simple system.

MECHANICAL DEMONSTRATIONS OF THE LAWS OF FORCE

Development of the Scott system of articulation has led to an examination of the laws of force which contribute to the process of mastication. Surprisingly enough, all of the basic laws of mechanics are involved, namely, the law of the lever, the wheel, and axle, the inclined plane, and the wedge. All of these are utilized in the various pieces of equipment which constitute the articulation system. Either consciously or unconsciously, the system was so designed that each law takes precedence at some point in the temporomandibular excursion. The maxilla remains stationary, as in the human jaw. The condyle head, in its glide in the glenoid fossa, is a manifestation of the action of the pulley in the law of physics. This explains why a perfect physiologic rest position can be maintained satisfactorily when equilibrium is thus established. This is true, even with neurotic patients, because their fears can be routed by a plausible explanation.

Boos[3] compares the glide of the condyle head "to a vehicle moving over a road," explaining that, while its movement is restricted within certain limits, there are nevertheless soft tissue investments of the joint which cushion the possible shock or friction inherent in forced action of the teeth during incisal performance.

By the same reasoning, whether in normal conditions or in malformations of the maxilla or mandible, the mechanical apparatus, developed to obtain precise centric maxillomandibular relations, is adjustable to a lateral oblique, anteriorly or posteriorly. Regardless of the slant of the occlusal plane, perfect articulation can be obtained on every cusp of both upper and lower dentures.

The laws of dynamic force are exhibited, (1) by the action of the lever, as manifested in the vertical movements of the mandible; (2) by the action of the

inclined plane in its lateral excursions and because of the difference in the superior point of the condyle heads which act as a fulcrum in affording a pivotal point for the balancing.

The theory of equalization determined, by the rotary point finder, is based on a corollary to the principle of the inclined plane. This compensates for the difference in the position of the condyle heads in much the same manner as a winding road around a mountain, or the thread of an ordinary screw. Mechanical scientists regard the law of the inclined plane as the most efficient for *exerting* force. As applied in the Scott system, it is so controlled as to eliminate the possibility of undue pressure on any of the adjacent tissues or organs, particularly the hearing.

Because of this illuminating insight on the basic law of dynamic force, neither prognathism nor retrusion could possibly present a complex problem. With a control established from one common plane, freedom of movement in the free-way space is assured. The immovability of the maxilla is the control factor, not only in obtaining the vertical dimension precisely but also as a component in establishing the mean in the retrusive, protrusive, and lateral strokes of the mandible.

In the horizontal movement, the force created by resistance—as in masticating food—is minimized by the wedge law virtue of the cusp type tooth and its multiple-contact properties. Also, equalized vertical pressure, afforded by the Scott method of computing angulation, minimizes the possibility of torque sensitivity; it enhances the action of the natural physiologic law of vascular circulation conducive to healthy oral tissue, both soft and bony.

COMPATIBILITY IN THE ORAL STRUCTURE

Gratzinger[6] has made a very worth-while study on dynamic irritation, analyzing the types of force to be encountered in mandibular action.

Kronfeld[7] points out the therapeutic effect of stimulating, equalized vertical pressure of the contact points. Goodfriend[8] refers to dentistry as a healing art. Niswonger[9] and Gillis[10] relate the true vertical dimension of the face to the physiologic rest position. Gardner[11] propounds the theory of necessary mineral intake and distribution by the blood stream induced by stimulation on the supporting tissues in controlling atrophy of the tissue and resorption of the bony arch. These postulates make necessary assimulation of the mandibular eccentricities of each individual in perfect denture fitting.

Nygard[12] points out clearly that the Scott system has been developed with the downward and forward movement of the lower jaw as the prime consideration, scientifically approximated by the extraoral tracing instrument. The recording instruments are designed for flexibility of movement and accurate reading of the mandibular drop to any degree. This same proponent also states that this system is the answer to most of the problems in denture construction, inasmuch as very little is left to guesswork. And, he indicates, the results are there to prove themselves in "better occlusion, better balance and equalized pressure, with a minimum of effort on behalf of the dentist." He does not fail to call attention

to the fact that the plane of occlusion can be obtained very quickly and accurately without guesswork. This, in turn, enables prosthetists to place correctly the teeth on the correct plane of occlusion. Sears[18] has recognized the merit of the accuracy it embraces.

The degree of angulation to permit the full swing of the mandible in its three-dimensional path is computed mathematically from a study of the natural laws of assimilation, discovered in exhaustive laboratory experiments. The instruments have been developed from scientific data, and made applicable to each individual patient from the initial measurements, from the use of the face meter to the final grinding-in. They have a wide range of adaptability, as well as adjustability in cases of problematic articulation. The various shapes of the mouth and slants of the occlusal plane encountered in patients requiring complete dentures can be approached with the most attenuate insight of the operator who possesses the means to reconcile a difference in incidence. Knowledge of the corollary afforded in the premise of the associated laws of force and adhesion eliminate anxiety of the end result. A somewhat exaggerated illustration of the complements and balance attainable for mastication or comfortable wearing of the dentures would be that of a high-wire walker, a juggler or a traybearer. Perfect balance is maintained in any engagement of the oral properties.

Schuyler[14] has pointed out that malocclusion is only one of many factors in denture prosthetics which may contribute to neurosis. Granting that the other factors are such as may be resolved by accurate diagnosis and proper evaluation of therapeutic procedures, it still may be the most contributing cause. In this case, it would not only be the most diverting factor to therapeutic aims but the most problematic in itself.

It is difficult to understand how there could be malocclusion present to any extent without its being an incipient cause to a nervous disorder. Lack of intelligent appraisal of the amount of bone present in the dental arch for support of the denture may produce a result somewhat obscured, but nonetheless effective, whether a result of resorption or dimineralization of the arch structure. A deformity or pathologic condition would not pose the same problem, for both conditions are easily identified. With a precision system for occluding the teeth, the uncertainty of the outcome for denture fitting would be greatly reduced, if not eliminated altogether. If not, it certainly would be a major contributing cause to a neurotic tendency.

Patients requiring complete dentures may have contracted certain tendencies as a result of the loss of dentition, such as interference with proper food intake and improper mastication of the food taken. With the proper stimulation of the tissue provided, a redeposit of minerals would result in restoration of the bony structure and the oral investments, and should be taken into consideration in making appraisals. Any prognosis short of this would be a direct contributing factor to probable trauma with all its neurotic implications. It would pose a problem in the attempt to maintain equalized stress of the cuspal contacts of the teeth in the denture. The cycle would then be repeated, for, obviously, complete

mastication of food could not be attained with improperly fitting dentures. Bodily nutrition would again be impeded and the problem increased. Therefore, malocclusion can be a direct cause of nutritional deficiency and systemic disorders, as well as an indirect impediment to the harmonious physiology of the organs.

In short, the susceptibility of tissue to rapid change would even present a problem in securing proper vertical dimension and free-way space in denture construction. Measurements are made from bone tissue in the precision system discussed here.

There is much in the dental literature to indicate that neurosis has become a problem with which the dentist must deal because of its effect on the muscles of mastication and consequent trauma of the oral cavity, as well as damage to the teeth in the dentition.[14-16] There is no indication that a lack of proper treatment of the mandibular movement in the making of dentures might be a basic cause.

Since neurotic conditions must be resolved by a therapeutic approach, the problem becomes even more serious when Schuyler[14] concludes that, in cases of mandibular prognathism or retrusion, it is impossible to place the central bearing point in the center of each arch; therefore, uneven "distribution of occlusal stress inaccuracies are inevitable,"—this in reference to the system of the Gothic arch tracing. Furthermore, from his discussion, as well as that of others in the dental field, it can be concluded that the Gothic arch tracing technique is accepted by dentists in general.

The Scott system propounds the technique developed by use of the Gothic arch tracer. One of the early recognitions of the end result was made by Libertin[17] during a laboratory demonstration in Chicago some years ago. He stated that the temporomandibular approximation was the nearest to the movement of the human jaw of any method extant.

A detailed discussion of the technique will explain the possibilities of flexible operations in meeting the problem of each patient individually and accurately. The method for computing mandibular angulation admits of a greater incidence of refraction in the dynamics of mastication than any previously propounded. This is most important in the lateral glide and meshing of cusp teeth.

THE METHOD

The technique is closely related in each step and follows the pattern of restoration indicated by the digital examination, study of the roentgenograms necessary for a complete diagnosis, and reasonably accurate predication of a prognosis. It is assumed that the preliminary details followed will be the same as in any other technique of full denture prosthesis.

Before the procedure is begun, the patient is given a true picture of the preliminary steps that are necessary to ascertain definite facial measurements. This is done to assure complete cooperation at all times. However, the technique and instruments used for measurement would produce the same results without any special effort on the part of the patient. The tedium caused by suspense is

sometimes overwhelming to the patient and causes unnecessary fatigue on the part of the dentist. It is good psychology to strive for relaxation and to establish perfect confidence between patient and dentist. Unless unforseeable situations arise in the course of a case, the entire procedure should require no more than three sittings.

EQUIPMENT AND MATERIALS

Because the prosthetic unit, as a whole, is somewhat complex in structure, and requires the proper correlation in its application, the data for its use will be described and illustrated step by step, and part by part.

Ten pieces of equipment constitute the complete prosthetic unit, seven for chair use, and three for laboratory use. Each instrument has a definite relation to the others. The technique developed requires that each be used in proper sequence from the beginning of the construction to the complete processing of the dentures. They consist of devices for determining the vertical dimension, centric relation of the sagittal registration, and the orientation of the occlusal plane.

The material used for the fitting and development of the partial or complete denture is: ordinary dental wax for the occlusion rims; modeling clay for the tracing plates, for the matrix; and two types of sticky waxes of a lower fusing point, for sealing purposes in the technique.

Cusp teeth are used. They are ordered to a precise scale as indicated by the cuspid nose meter. This instrument indicates the amount of bone surface available for mounting and balancing the denture in proper synchronization with the condyle path.

The cusp tooth is the type best suited for assuring equal point-to-point stress in the masticatory process. This coincides with a study made by Schneider[18] of occlusal surfaces and their part in facilitating the mastication of food "under decreased masticating pressures." He has made a close observation of the merit of multiple-surface contact, as well as new scientific methods for processing "scissors-like" cuspal points which are resistant to wear, although the tooth for which he is credited has a thinner structure than the ordinary twelve-point contact surface used. However, the contour in the plane of the dental arch is the same. He stresses the function of this type of tooth, and its advantages in cases of prognathism or retrusions, even in instances where accurate occluding has been heretofore disregarded. Thus, Schneider, in his patent papers describing the purpose of his projected theory, mentions the perfect meshing of the cusps and depressions of the grinding teeth. This applies to ordinary occlusion and to malformations. He concurs with many others in the prosthetic field that the cusp tooth is the most satisfactory.

STEP I

The preliminary impressions are made with modeling compound, and plaster casts are poured. From these casts, individual trays are built. Accurate impressions are made in the individual trays with an alginate impression material.

Gray rock is used for the working casts as it leaves the margins and borders much more definite.

The occlusion rims, made of regular base wax and chilled, are placed accurately on the baseplates. They are then placed in the mouth and are knife-trimmed to the length of the upper lip, anteriorly.

STEP II

The bite plate leveller (Fig. 1) is an instrument which consists of two flat, horizontally curved, parallel bars (upper, spacer bar, and lower, guide bar). It is used to establish the orientation of the plane of occlusion. The spacer bar is allowed to contact the upper occlusion rim, and the guide bar is adjusted to rest just below the membraneous septum of the nose. It is placed on the face to conform with the ala tragus line, where crayon markings are made to establish "landmarks."

The center screw (Fig. 1,*A*) is first adjusted to the anterior length, then the two side screws (Fig. 1,*B* and *C*), are adjusted so that both bars are exactly parallel to each other.

The top bar is an eye leveller (Fig. 1,*D*). The patient is asked to look at a fixed object on the same horizontal plane with the pupil of the eye, while the leveller is adjusted to that same plane. A check is made to ascertain that both pupils fall in that horizontal plane. In so doing, the operator makes certain the leveller bar is exactly parallel with the guide bar, both before and after the screws of the indicator are tightened, by using the millimeter ruler or caliper. A double check is made on the position of the eye leveller after the screws are tightened to make certain the original position is retained.

The upper occlusion rim is removed when the proper height of the anterior part has been established. The height of the posterior part of the occlusion rim is trimmed until it coincides with the ala tragus line as indicated by the spacer bar (upper).

The face meter is used to establish the proper vertical height (Fig. 2). These measurements are taken from bone tissue to bone tissue to eliminate the error of measurements made from movable tissue. Screws *A* and *B* are equipped with small pointed indicators for marking purposes.

Screw *A* is adjusted so that its indicator touches the inner canthus of the eye. Screw *B* is adjusted so its indicator touches at the junction of the ala of the nose and the levator labii ala. This indicator can be raised and lowered to accommodate the length of any nose. A mark with a crayon is made at the ala of the nose where indicator *B* is set. Screw *C* locks the position bar which controls length. It in no way affects the measurements. Plate *D* is adjusted to the incisal edge of the occlusion rim. Screw *D* regulates lipline measurement. The attachment is movable to determine the lipline. It is turned to the side during the measurement to avoid interference with the lip or occlusion rim. Screw *E* is placed at the gnathion on the mandible. The combined distances from *A* to *B* (from the inner canthus of the eye to the ala of the nose) and

from *A* to *D* (from the inner canthus of the eye to the edge of the lip) equal the distance from *A* to *E* (from the inner canthus of the eye to the gnathion on the mandible). The lower occlusion rim is trimmed to accommodate these measurements.

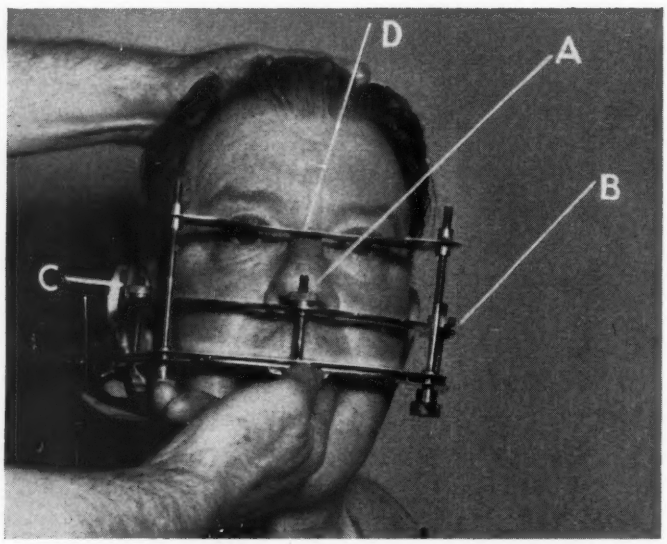

Fig. 1.—The bite plate leveller has two flat horizontal bars. The middle bar is the spacer bar. The lower bar is the level or guide bar. The bars are adjustable by means of three spacer screws *A*, *B*, and *C*. The upper bar is the eye leveller bar *D* which is attached to the plate leveller. It is adjusted level to the line through the pupils of the eyes. The guide bar is adjusted parallel to the eye leveller bar and to the ala tragus line. The spacer bar is adjusted parallel to the guide bar and at the height of the occlusal plane. An instrument is attached to the spacer bar which is placed in the mouth to shape the occlusion rims according to the ala tragus line and the eye level line. This is to establish the orientation of the occlusal plane.

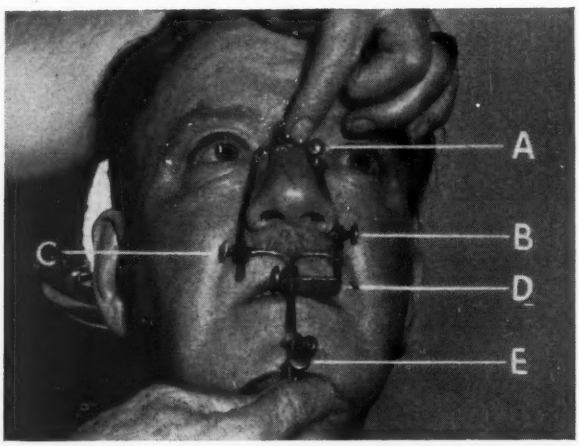

Fig. 2.—The face meter is used to establish the vertical dimension. Facial measurements are taken from the inner canthus of the eye, *A*, to the ala of the nose, *B*, and from the inner canthus of the eye, *A*, to the lipline, or to the incisal edge of the occlusion rim, *D*. These combined measurements equal the distance from the inner canthus of the eye *(A)* to the gnathion *(E)* on the mandible to indicate the proper vertical dimension. *C*, The position bar.

It should be noted that the face meter is held firmly in position, according to the position of the indicator at the inner canthus of the eye, while the other adjustments are being made. This procedure conforms with the proper placement of the condyle in the glenoid fossa, and the proper vertical height is established regardless of the free-way space. With this system, the operator is able to record accurate measurements and restore an edentulous case to the proper vertical height. When the measurements are once taken, they are maintained throughout the processing of the dentures. In other words, the screws, once set in the positions established, remain untouched until the dentures are completed.

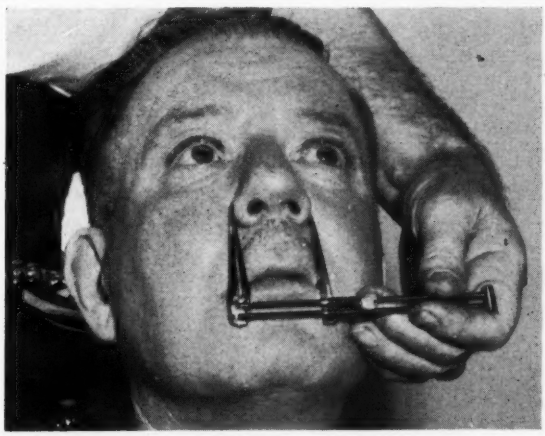

Fig. 3.—The cuspid nose meter is used to measure the width of the six anterior teeth.

STEP III

The nose cuspid meter (Fig. 3) is used to measure for the width of teeth. It is the smallest instrument in the unit, but it serves a very definite purpose in time saving and accuracy of measurements to determine the exact width of teeth to be used. By establishing the width of the six anterior teeth, it simultaneously registers the curve of the dental arch. This measurement is taken from one ala of the nose to the other ala. While the patient is in a breathing pause, the indicators are adjusted to the nose. The distance between the indicators is the distance from the apex of one cuspid to the apex of the other. This distance coincides with the carding of anterior teeth.

The occlusion rims are sealed together, with a piece of wax of a lower melting point, while they are in the mouth. A mark through both rims is made with the point of a knife, directly underneath the nose, in line with the labial frenum. Another is made on either side of the lip in the position of the bicuspid, for convenience in matching on the articulator.

STEP IV

The Gothic arch tracer makes records both extraorally and intraorally. It consists of three parts, the central bearing table for recording the balance of the occlusion rims (Fig. 4,*A*); the stylus for determining the integrated occlusion (Fig. 4,*B*); and the extraoral tracing table (Fig. 4,*C*), on which the recordings are made. The stylus and the tracing table are referred to as the extraoral Gothic arch tracer. The height of the central bearing screw is adjustable, by means of a detachable lever, while it is in the patient's mouth. The stylus contacts tracing table coincidentally with the registration of the central bearing table (Fig. 4).

The stylus and tracing table are visible at all times and are adjustable to accommodate any size occlusion rim. The stylus is mounted on the upper occlusion rim in niches made in the wax which correspond with the markings on the anterior and sides of the occlusion rims (Fig. 4,*D*). The tracing table and central bearing point are mounted on the lower occlusion rim. These devices are sealed to the occlusion rims with wax of a lower fusing point, which will hold them in position when they are transferred to the articulator. The tracer must be attached so it cannot possibly move. A straight-line articulator is used for this operation. All mountings on articulators are secured with plaster.

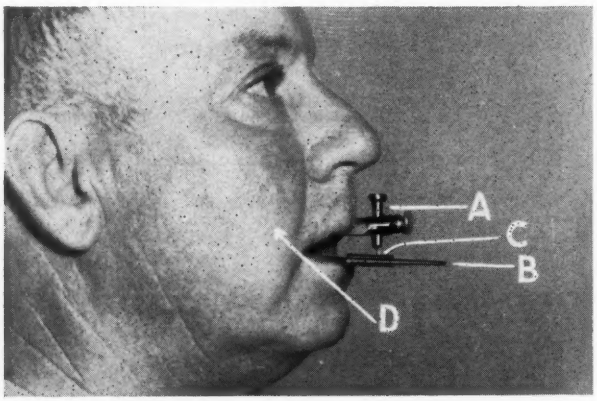

Fig. 4.—The extraoral Gothic arch marker with an adjustable central bearing point. *A*, The stylus to which is attached the central bearing table. *C*, The tracing table on which the Gothic arch tracing is made. *B*, Extensions to which other apparatus is attached. *D*, The location of the marks on the occlusion rims.

The occlusion rims are removed from the straight-line articulator and returned to the patient's mouth for the registration of centric relation. It should be noted that three major recordings are taken while the occlusion rims are in the patient's mouth for the second time: (1) the Gothic arch tracing; (2) the sagittal marking of the mandibular drop, and (3) the centric relation. All of these are to be reproduced on the mandible-movement articulator.

To make the occlusal registration, the central bearing screw is first adjusted to a height comparable to that of the stylus in its contact with the tracing table. Then the extraoral table is adjusted for length and locked into position to receive markings from the stylus. The intraoral recording is made on the central bearing

plate. Both the intraoral and extraoral plates are colored with crayon to register the markings. Now the Gothic arch tracing is recorded, both intra- and extraorally, by asking the patient to move the mandible from side to side, alternately, pausing in the center at the finish of each stroke.

STEP V

The next step is to find the rotation point of the condyle. The rotary point finder is attached to the Gothic arch tracer and is used to register the position of the head of the condyle in the glenoid fossa (Fig. 5). This instrument extends back to the hinge of the jaw to register the opening and closing jaw movements. The rotary point is at the head of the condyle. When the exact point has been located, the position is marked with a dot made by an indelible pencil. This rotary point will coincide with the path of rotation within the oral cavity. The head of each condyle may be in a different vertical or horizontal plane. An accurate registration of the position of each condyle is important in reproducing motion in the arcuate plane on the articulator.

Fig. 5.—The rotary point finder attached to the Gothic arch tracer.

STEP VI

The rotary point finder is detached from the Gothic arch tracer, and the sagittal marker is adjusted in its place. This instrument is equipped with two plastic plates, one on either side, to register the paths of the condyles in the glenoid fossae (Fig. 6). The tables must be parallel with the ala tragus line to determine the exact inclination of the paths of condyles. Registration is made on a special device which records the protrusive stroke made by the patient independent of assistance from the operator. The point of the sagittal marker must be placed at the exact point on the face which was previously located by rotary point finder. The plastic plates are adjusted in place over the condylar region and colored with brown crayon to register the tracings. They are held in position over the condyles by the bridge support across the nose (Fig. 6,*A*).

The protrusive stroke is recorded by asking the patient to thrust the mandible forward. The registration is made from the apex of the Gothic arch tracing which was previously registered. The sagittal drop of the condyle is determined simultaneously.

The angulation of the mandibular drop is indicated on the plastic degree plate (Fig. 7), as the mandible makes the protrusive stroke. It should be noted that all jaw movements are alike, except in angulation. The angle of downward and forward movement of the condyles can be measured and transferred to the articulator, by the extraoral method. This procedure has been designed to scientifically and accurately register the angle of the mandibular drop. By this method, the plane of occlusion can be obtained very quickly and accurately and without guesswork. It enables the dentist to place the teeth on the correct plane of occlusion. When the mandibular movements are ascertained, the molars will mesh without any cuspal interference.

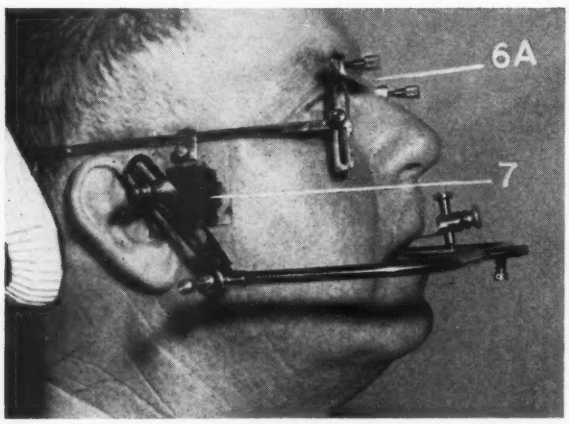

Fig. 6.

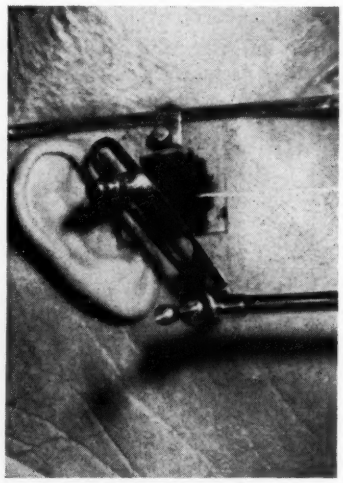

Fig. 7.

Fig. 6.—The sagittal marker supported in position by the Gothic arch tracer and the bridge support across the nose. The marker is adjusted to contact the plastic tracing plates at the points located by the rotary point finder. *A*, The bridge support.

Fig. 7.—The plastic degree plate which is adjusted in the sagittal plane parallel with the ala tragus line.

The different positions of the condyle head have been taken into consideration. Therefore, the paths of the mandible during its various excursions and returns to the centric or physiologic rest position have been recorded. It is the flexibility incorporated into the prosthetic unit that allows it to move freely, yet congruously, in its movement on *varying* rotation axes to the position where the teeth come into equalized point-to-point contact.

When the protrusive stroke has been registered, a hole is made in the apex of the Gothic arch registration with a punch, so that the jaw will close with the stylus in the hole. The patient is asked to open his mouth, and plaster is applied on the ridges of the occlusion rims. The patient is then directed to close until the central bearing point contacts the intraoral tracing table, and the point of the stylus drops into the hole in the extraoral tracing table. Thus, the correct centric relation is recorded.

STEP VII

The sagittal marker is removed from the Gothic arch tracer and the face-bow is attached. The face-bow is equipped with ear supports that are locked into position with the placement attachments directly on the dot previously located with the rotary point finder (Fig. 8).

The anterior lock on the face-bow is tightened, the ear supports are released, and the sealed occlusion rims are transferred from the mouth to the articulator (Fig. 9). The instrument is equipped with a condyle adjustment regulator, an incisal table with incisal registration markers which are used in conjunction with Gothic arch tracing registration. Opening and closing the mandible is unnecessary in this mounting.

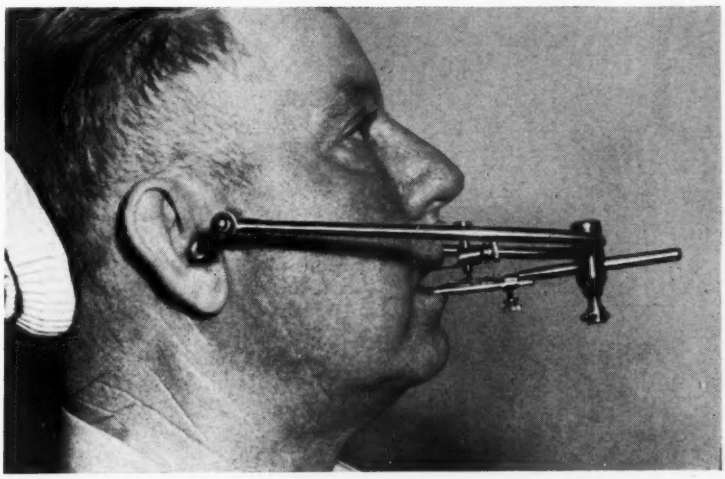

Fig. 8.—The face-bow with ear supports in position and attached to the Gothic arch tracer.

The condylar settings are made on the articulator according to the tracings obtained by the sagittal markers and according to the cuspal inclination of the conventional tooth, which is 20 degrees. This is the function of the fixed template (Fig. 10). When it is placed in position on the articulator, it will accommodate the templates designed by tooth manufacturers. This provides for a perfect curvature of the occlusal plane for each individual make of teeth. Its further functions are to maintain the height of the occlusion rims and all levels previously taken from mouth with the leveller. It is so constructed as to be adjustable to all positions anteriorly, posteriorly, and vertically. The occluding rod maintains the vertical dimension (Fig. 11).

ESTABLISHING INCIDENCE IN ANGULATION

In making the computation for adjusting the articulator, one-half the sum of the readings on the plastic plates are deducted from twice the figure denoting the cuspal inclination of the teeth, and that result is used as the setting of the articulator. For example, a hypothetical case has a sagittal condylar registration of 20 degrees on one side and 10 degrees on the other side. The sum of these

registrations is 30. One-half of that sum is 15. The teeth to be used have cusps with 20 degree inclinations. Twice 20 is 40; 15 deducted from 40 is 25, the figure that is used for setting the articulator.

The incisal table and registration markers are set at *A* and *B* (Fig. 9). The opening and closing movements which occur at *C* are independent from the mandibular movement of the articulator and are adjustable to the desired degree

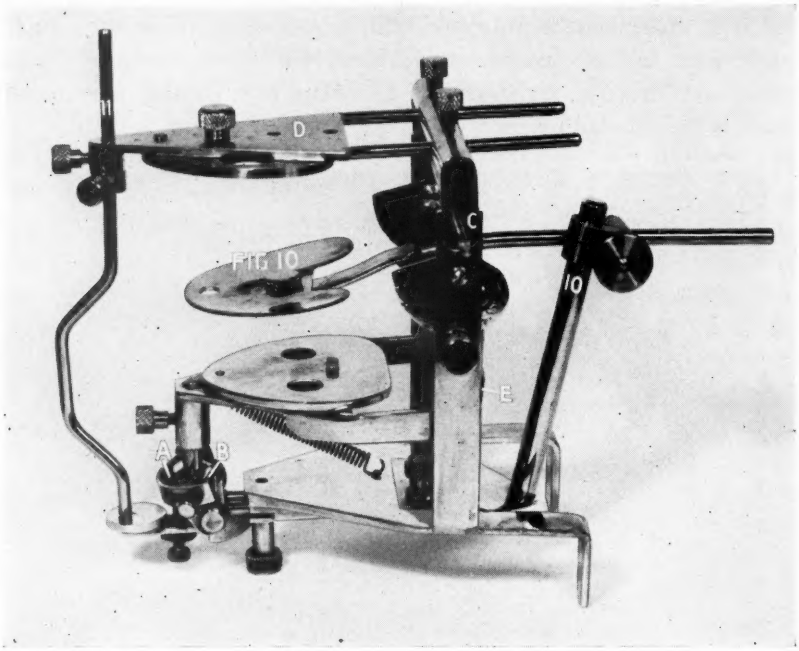

Fig. 9.—The articulator. The mandibular member is provided with movement while the maxillary member is fixed except for opening and closing. The incisal table is adjustable for inclination and to conform to the Gothic arch tracing at *A* and *B*. Opening of the instrument which is independent from the mandibular movement occurs at *C*. The upper bar, *D*, is adjustable forward or backward. The shift bar, *E*, is equipped with finger control for protrusive movement.

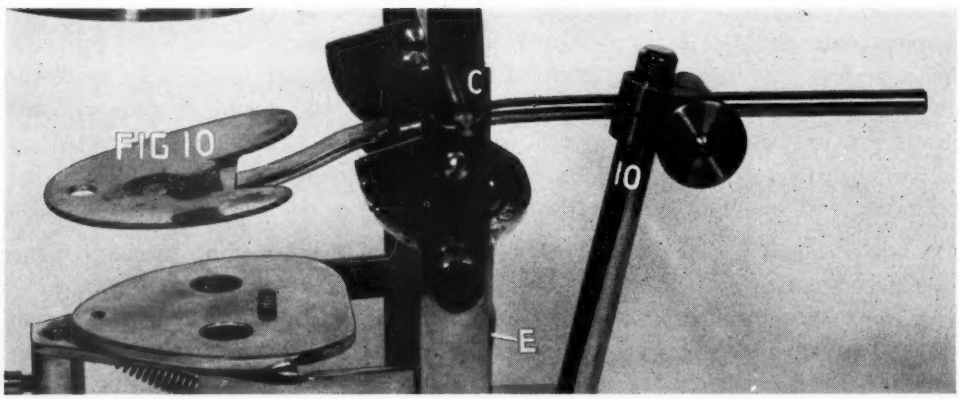

Fig. 10.—The fixed template which is adjustable to any position or angulation. It conforms to the type of tooth used and to the position indicated by the records made at the mouth by the other instruments.

of opening. The upper bar, *D*, can be regulated backward or forward, and the anteroposterior movement can be retained at the location desired by adjustment screws. The occlusion rim retainers are detachable for cleaning purposes.

The shift bar is equipped with a finger control shift for protrusive movement, *E*. When the teeth have been set up and occlusal adjustments have been made, the occlusion rims are removed, and the dentures are processed and made ready for fitting and insertion.

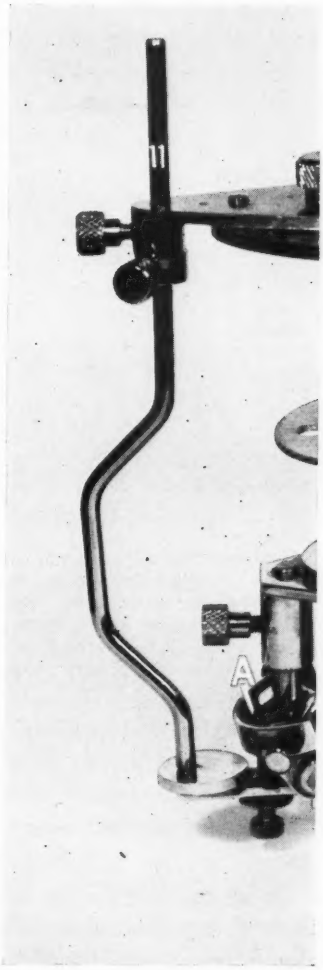

Fig. 11.—The occluding rod that maintains the vertical dimension.

FITTING AND GRINDING-IN

The completed dentures are inserted in the patient's mouth; the patient is asked to close on them in centric relation, and a wax check bite is taken in occluding wax. This check bite is made with a certain degree of pressure, but the patient is warned not to close entirely through the wax.

The dentures are then mounted on the articulator of the milling machine (Fig. 12). The lower denture is mounted first, using plaster to hold it in place.

The milling machine is started on the protrusive stroke and is allowed to pass as far forward as the incisal edge-to-edge contact will permit. Then the setting of the eccentric is changed, with the adjustment for the condyle registration at the back of the machine. (Fig. 12,*A*). The lateral stroke is regulated by turning the screw (Fig. 12,*B*) one-half way around from the right to the left.

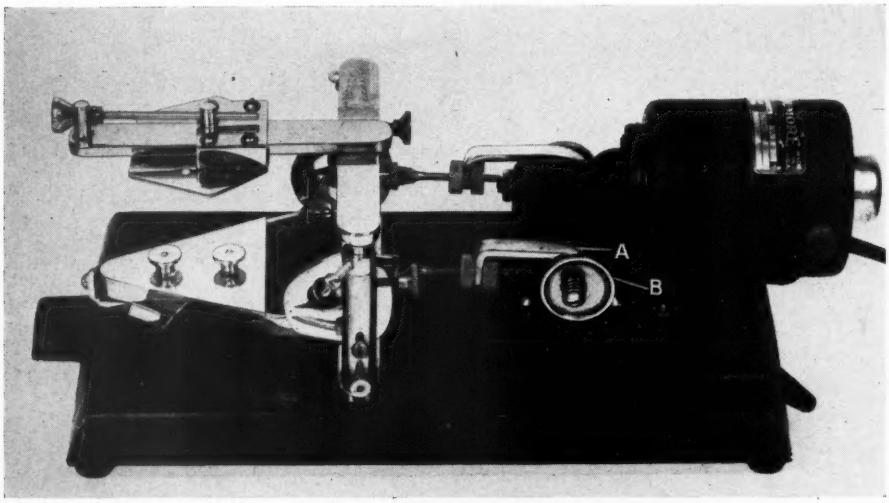

Fig. 12.—The Scott milling machine. The adjustments are made from the sagittal markings, and are made to conform to the condyle settings on the articulator. The dentures are mounted in the machine by means of a wax check bite. The stroke is controlled to prevent an excessive amount of movement which might cause tooth breakage. Movements are produced to permit the same contacts of teeth as in the natural function in the mouth. *A*, The condyle adjustment. *B*, The lateral stroke adjustment screw.

The grinding-in process with the Scott milling machine embodies not only the precision registration of the natural action of the maxilla and mandible in the masticatory process but also the reproduction of the function of the dentures. It offers a means of visible study in free-way movement and centric occluding. It provides an expeditious method of spot grinding, should there be any adjustments necessary. Most of all, it psychologically identifies the patient with an external object which he immediately relates as a part of himself. With this pattern of perfect functioning already established in his thinking as a result of his own observation of the milling machine demonstration, physical effort in adapting the dentures to the mouth becomes less evident, while satisfaction becomes more pronounced.

SUMMARY

Summarizing, there are seven pieces of equipment for chair work, namely, (1) the face meter; (2) the face-bow; (3) the bite leveller; (4) the nose cuspid meter; (5) the Gothic arch tracer; (6) the sagittal marker, and (7) the rotary

point finder; and three pieces of laboratory equipment, (1) the template; (2) the articulator, and (3) the milling machine.

The technique embraces three-dimensional occlusion. The principle applied to registration of occlusion on the articulator is the mandibular movement, as in the human jaw. The cusp-type tooth is used. From the first examination to the delivery of the dentures, only three sittings are required.

The system attacks the problem from the therapeutic standpoint by providing proper exercise of the oral structures by providing equalized pressure in point-to-point contacts of every tooth in the dental arch.

The principle embodied in the process simulates the natural laws of the oral anatomy. It provides a masticating mechanism that moves absolutely free and frictionless at all points of cusp contact, anteriorly and posteriorly and in the alternate lateral strokes.

CONCLUSION

The author believes that the more progressive minded will become increasingly more intolerant with any system that is based on procedures that are contradictory to quality, economy, or harmony of relations, whether it be in the field of business, the professions, or science; that the time element will be the deciding factor with both the profession and the layman when outlays of moneys are involved and satisfaction assured; that no dentist will uphold a technique that is based on empirical laws of reasoning when he has been made cognizant of the anatomic relations, and that every dental college will embrace in its teaching only the systems which are most efficacious.

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303½ South Main Street
Pratt, Kansas

SURFACE HARDNESS, COMPRESSIVE STRENGTH, AND ABRASION RESISTANCE OF INDIRECT DIE STONES*

F. A. PEYTON, D.Sc., J. P. LEIBOLD, D.D.S., M.Sc.D.,** AND G. V. RIDGLEY, D.D.S., M.Sc.D.***

Department of Metallurgy, School of Dentistry, University of Michigan, Ann Arbor, Mich.

THE common use of the indirect method in the preparation of inlays, three-quarter and full crowns, various bridge forms, and other dental castings, together with the appearance on the market of newer type gypsum products for use as dies, indicates a need for more knowledge of some of the physical properties of the quick-setting artificial stones. In addition, an understanding of the best method of die preparation is necessary in order that the stone may be used to its fullest advantage. Every dentist who includes in his practice gold castings, or other precision techniques requiring dies, should have a thorough knowledge of the factors involved in the fabrication of the die which lead to its improvement. Such a study should enable him, with a minimum of extraneous effort, to produce the most satisfactory stone die obtainable by practical methods.

Recently, much has been written about the hydrocolloid technique for use in crown and bridge procedures. Special equipment for taking agar impressions has received widespread recognition, and the accuracy of the material is acclaimed by many dentists as superior to that of other impression materials. This method of impression making, however, requires that the operator use artificial dental stone as a die material inasmuch as no other well-accepted method appears practicable. Amalgam cannot be packed readily into the hydrocolloid impression because of the frailty of the impression material. The hydrocolloid impression cannot be copperplated unless special preparations and extremely careful methods are employed, although some operators have succeeded in accomplishing this. The technique is not a simple one, however, nor can it be done with the equipment generally found in the average dental office.

The regular and improved dental stones have been found to be reasonably satisfactory as a die material to be used in conjunction with the hydrocolloid impression materials. In the past, objections have been made to the use of dental

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**Now in private practice in Phoenix, Ariz.

***Now teaching at Howard University, Dental School, Washington, D.C.

stone as a die material because it was believed that it lacked hardness and strength and that it was not resistant to abrasion during finishing operations. On the other hand, dental stone is inexpensive, simple to manipulate, rapid in setting, and has sufficient dimensional stability to be reasonably satisfactory for dies.

It was the purpose of this study to investigate the properties of hardness, strength, and abrasion resistance of various products when subjected to special treatments of soaking in oil or water for different periods of time. A further comparison was made of stones normally manipulated and after being centrifuged. Comparisons were made also of the properties of regular dental stone and the newer improved stones.

The dental literature contains several references which give detailed techniques for the use of dental stone as a die material, but investigations based on the measurement of properties of die materials are quite limited. Paffenbarger and Beall[1] investigated four gypsum products used for indirect inlay models. The properties of setting time, compressive strength, and linear setting expansion were measured. From these studies they concluded that the physical differences between different products were too little to be of practical value. The method of testing accuracy consisted of determining the fit of gold mesio-occluso-distal castings on the die and on the models.

Recently, a report by Mahler[2] indicated that a definite correlation exists between hardness and compressive strength of gypsum materials. He concluded that hardness serves as a satisfactory criterion of the surface condition of the material; this seems appropriate for die materials inasmuch as the die is rarely broken, but may be readily marred on the surface. The surface hardness is also indicative, to some extent, of the abrasion resistance and flow properties of the stone.

Peyton and Mahler[3] have discussed the use of the Rockwell Superficial Hardness Tester for the determination of the hardness of dental plasters and stones. For this work a ½ inch steel ball penetrator and a 15 kg. major load were employed. The results indicated that the improved stones are superior to regular dental stone for dies on the basis of comparative hardness.

The dimensional change of dental stones during setting has been studied by Thompson.[4] He observed that stone models poured immediately, which have a hygroscopic expansion of 0.0023 to 0.0028 inch per inch, are sufficiently accurate to construct dental restorations that fit the mouth and the models.

EFFECT OF STORAGE TIME AND CENTRIFUGING

Three die stones, Duroc, Diolite, and Vel-Mix, were tested for setting time and for surface hardness after room condition storage times of one hour, three days, and two weeks. The samples were vibrated and centrifuged into the test rings to determine if any difference existed between the two methods.

In handling these materials, certain precautions were taken to insure uniform samples. These precautions consisted of (1) shaking the material before removing a sample so as to minimize particle size segregation, (2) weighing the material

in a balance and then closing the can immediately, (3) placing a measured quantity of water into the mixing bowl which had been wet, then damp dried, to prevent absorption of water by the bowl, (4) sifting the material into the water within a time range of fifteen to twenty seconds, (5) spatulating for one minute then vacuumizing for thirty seconds, (6) filling the molds by vibration, (7) covering all specimens with a glass until the final setting had taken place, and (8) storing all specimens in air at room temperature so as to simulate average laboratory conditions. The centrifuged specimens were obtained by centrifuging into 16 mm. sections of one-half inch split copper tubing. A Torit cast-centrifuge unit was used.

Hardness measurements were made with a Rockwell Superficial Hardness Tester using a ½ inch ball and a 15 kg. load.

The average initial and final setting times of the three stones, measured by the Gillmore needle, are given in Table I, together with the powder-liquid ratios used. It will be noted that the maximum difference in setting time of different products was less than three-fourths of a minute. These values represent averages from five or more samples.

TABLE I. AVERAGE SETTING TIMES AND POWDER-LIQUID RATIOS OF THREE IMPROVED STONES

MATERIAL	POWDER-LIQUID RATIO	INITIAL SET (MINUTES)	FINAL SET (MINUTES)
Duroc	100/23	9.68	11.59
Diolite	100/25	9.25	11.50
Vel-Mix	100/22	8.86	11.00

A comparison of the weight loss and Rockwell Hardness Numbers of the three stones under normal manipulation after storage times of one hour, three days, and two weeks at room conditions is given in Table II. It should be noted that the percentage weight loss is essentially the same after one hour, but at longer time intervals a greater loss occurs in the cases where there was a lower powder-liquid ratio. The difference in weights is not believed to be significant. A definitely lower hardness value was noted in the case of Diolite than in other products at longer time intervals. Duroc and Vel-Mix were essentially the same.

TABLE II. AVERAGE ROCKWELL (15Y) HARDNESS AND PERCENTAGE WEIGHT LOSS OF THREE IMPROVED STONES AFTER STORAGE

MATERIAL	STORAGE TIME					
	ONE HOUR		THREE DAYS		TWO WEEKS	
	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS
Duroc	78.82	1.32	91.85	2.94	91.40	2.94
Diolite	79.10	1.30	89.10	3.60	89.77	3.54
Vel-Mix	82.30	1.30	92.00	2.42	92.15	2.51

A study of centrifuged and vibrated mixes was limited to one stone, Duroc, since there was little difference noted among the three stones. It is obvious from Table III that centrifuging does increase the surface hardness after one hour, but has no effect on this property after longer storage intervals. It is possible that the centrifuging removed some residual water, accelerating the setting time and the hardness. The results in Table II indicate that an increase in hardness accompanies the loss in residual water, with a three-day period representing equilibrium conditions. These results indicate that centrifuging may be beneficial if it is necessary to use the die within a short time.

TABLE III. AVERAGE ROCKWELL (15Y) HARDNESS OF CENTRIFUGED AND NONCENTRIFUGED SPECIMENS OF DUROC IMPROVED STONE AFTER STORAGE

CONDITION	STORAGE TIME	
	ONE HOUR	TWO WEEKS
Centrifuged	82.28	89.73
Noncentrifuged	77.82	91.40

EFFECT OF OIL IMMERSION AND WATER IMMERSION

Four products were tested in this investigation. These consisted of two regular dental stones, Albastone and Castone, and two improved stones, Duroc and Vel-Mix. Three tests were used as methods of comparison of the dental stones. The first consisted of a hardness test performed with a Rockwell Superficial Hardness Tester in the manner described by Peyton and Mahler.[3] Hardness measurements were made on specimens poured into a ring ½ inch thick and 1⅝ inches in diameter. The second test consisted of a determination of the crushing strength on cylindrical specimens 1¼ inches in diameter and 2¼ inches long. These tests were conducted with a Tinius Olsen gear and screw-type machine. The third test consisted of the determination of the weight loss of specimens ¼ inch in diameter and 2 inches long shown when subjected to abrasion. A unit was designed for this purpose, as shown in Fig. 1. This unit consisted of a rotating abrasive disk and an arm capable of variable loading. Two speeds, 33⅓ r.p.m. and 78 r.p.m., were used, and the disk was equipped with several sandpaper abrasives ranging from fine to coarse. The counterpoised arm permitted any desired load to be attached, and the movement of this arm could be regulated with a powerstat connected to a drive motor. Weight loss was determined by making initial and final weighings after the specimens were subjected to definite loads for fixed times under the same rotational speeds and with the same grit abrasive.

Materials were obtained through the normal trade channels open to any member of the dental or allied profession. The final setting times of the materials were determined with the Gillmore needle, and testing times of one hour, one

day, three days, and one week after these final setting times were selected for the hardness measurements and abrasion loss. Specimens in compressive strength tests were aged for two weeks to insure complete drying.

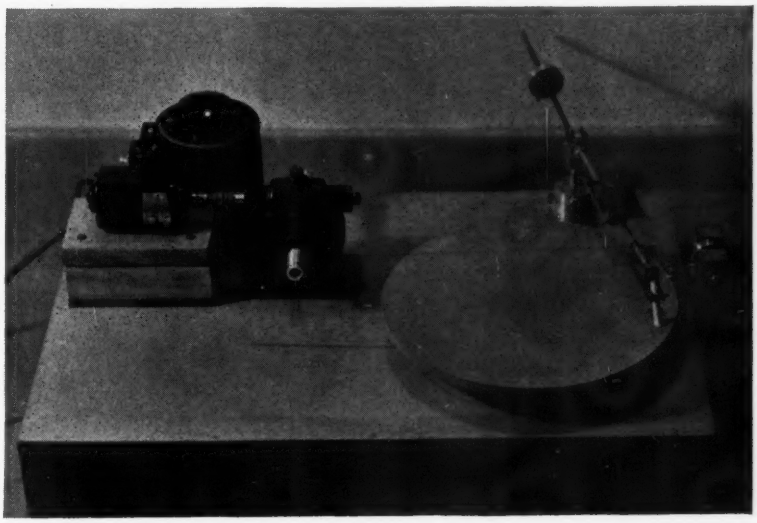

Fig. 1.

Three groups of samples were used for the hardness tests. The first set served as a control and was untreated after setting; the second and third groups were placed in oil or water one hour after the final set. The specimens were placed under a vacuum in oil or water for five minutes to remove as much air as possible. They were then allowed to remain in an oil or water bath for twenty-four hours. The immersion of the sample in water was omitted in the abrasion tests, and tests were limited to only two products.

TABLE IV. AVERAGE ROCKWELL (15Y) HARDNESS OF FOUR DENTAL STONES AFTER STORAGE

MATERIAL	POWDER-WATER RATIO	STORAGE TIME						
		ONE HOUR	ONE DAY		THREE DAYS		ONE WEEK	
		RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN
Duroc	100/23	79.9	2.36	79.5	2.55	90.6	2.94	91.6
Vel-Mix	100/23	82.3	2.12	78.4	3.66	88.9	2.53	91.3
Castone	100/31	56.9	2.32	54.3	5.26	77.6	5.24	83.1
Albastone	100/33	54.7	4.79	57.9	6.23	71.3	7.30	84.6

Obviously, such a procedure was not possible in the case of tests made one hour after setting. In this case, the procedure was adapted by waiting fifteen minutes after the final setting time and then placing the specimen in the bath, under vacuum, for five minutes after which it was removed and drained for fifteen minutes. The specimens were then tested.

RESULTS

Initial tests consisted of a determination of the hardness and change in weight of the specimens in the untreated, oil-treated, and water-treated states. The weight change was not determined for the one-hour test because of insufficient time. The averaged results of the hardness tests and the changes in weight, based on three specimens for each condition, are given in Tables IV, V, and VI.

TABLE V. AVERAGE ROCKWELL (15Y) HARDNESS AND WEIGHT CHANGE OF FOUR DENTAL STONES IMMERSED IN OIL

MATERIAL	STORAGE TIME						
	ONE HOUR	ONE DAY		THREE DAYS		ONE WEEK	
	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN
Duroc	77.8	0.88	75.6	0.98	83.0	1.17	85.4
Vel-Mix	79.7		79.3		82.2		86.6
Castone	58.5	0.60	59.1	2.14	62.9	4.04	76.3
Albastone	58.1	1.28	57.9	1.60	52.1	3.03	73.1

TABLE VI. AVERAGE ROCKWELL (15Y) HARDNESS AND WEIGHT CHANGE OF FOUR DENTAL STONES IMMERSED IN WATER

MATERIAL	STORAGE TIME						
	ONE HOUR	ONE DAY		THREE DAYS		ONE WEEK	
	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN	% WEIGHT LOSS	RHN
Duroc	76.3	0.58	77.1	2.28	84.9	3.02	91.5
Vel-Mix			80.4		85.4		91.0
Castone	56.9		57.4		75.6		83.2
Albastone	55.1	0.06	59.2	6.53	82.2	6.97	82.7

TABLE VII. CRUSHING STRENGTHS OF FOUR DENTAL STONES

MATERIAL	CRUSHING STRENGTHS, PER SQUARE INCH				
	UNTREATED		OIL TREATED		WATER TREATED
	WET	DRY	WET	DRY	DRY
Duroc	5,700	9,000	5,000	6,500	8,100
Vel-Mix	5,900	8,500	4,900	6,800	7,600
Castone	4,000	7,300	3,300	4,300	6,400
Albastone	3,600	6,200	3,200	4,500	5,600

Crushing strength tests were determined for the untreated, oil-treated, and water-treated conditions. Both wet and dry strengths were determined with the exception of the water treatment where the test was limited to a determination of the dry strength. Wet tests were made twenty-four hours after setting. Dry test specimens were aged two weeks. The averaged values based on three or more samples are given in Table VII.

Abrasion tests were conducted with a coarse grit material. The specimens were on the rotating disk for fifteen seconds, and they were subjected to loads of 250, 500, 750, and 1,000 Gm. Tests were limited to one improved and one regular dental stone in both the untreated and oil-treated states after one day, three days, and one week. Results in Table VIII are limited to samples subjected to a fixed load after being aged for different times. Table IX indicates the abrasion loss of specimens aged three days, then abraded with three different loads.

TABLE VIII. AVERAGE PERCENTAGE ABRASION LOSS OF TWO DENTAL STONES

MATERIAL	GRAMS LOAD	UNTREATED			OIL TREATED		
		ONE DAY	THREE DAYS	ONE WEEK	ONE DAY	THREE DAYS	ONE WEEK
Duroc	500	9.39	2.98	1.85	7.14	3.25	2.12
Albastone	250	4.90	3.68		4.75	4.07	

TABLE IX. EFFECT OF VARIABLE LOAD ON ABRASION LOSS PERCENTAGE OF TWO DENTAL STONES AFTER THREE DAYS

MATERIAL	UNTREATED			OIL TREATED		
	250 GM.	500 GM.	1,000 GM.	250 GM.	500 GM.	750 GM.
Duroc	1.35	2.98	6.47	0.55	3.25	5.66
Albastone	3.68	6.11	12.30	4.07	5.60	11.50

DISCUSSION OF RESULTS

An examination of the results in Table IV indicates that three days is sufficient to attain maximum hardness for special stones. The two improved stones are essentially the same. A longer time is required in regular dental stones for maximum hardness to be reached. Here again, the regular stones are essentially the same, based on the hardness values. However, a definite increase in hardness is noted in the case of the improved stones when compared to the regular dental stones. The change in weight did not follow a definite pattern. This could be due to a variation in the room humidity in some cases or simply a variation in equilibrium conditions.

The only noticeable effects of oil immersion (Table V) were a decrease in the over-all hardnesses of the stones and a definite decrease in the percentage of

weight loss. The water treatment did not affect the weight loss, but did increase the time necessary to attain maximum hardness in the case of the improved stones. The regular stones were not significantly affected, as shown in Table VI.

An examination of Table VII indicates that the wet strengths are definitely lower than the dry. Here again the improved stones were very similar, as were the regular ones, but the improved stones were appreciably stronger than the regular stones. Both water and oil treatments caused a pronounced decrease in the dry crushing strengths when compared to the untreated values. This was also noted in the case of the wet strengths of the oil-treated specimens when compared to the untreated specimens.

The abrasion test results are given in Tables VIII and IX. In Table VIII an improved stone is compared with a regular stone after they have been aged one day, three days, and one week in the untreated and oil-treated conditions. It is obvious that the improved stone is much more resistant to abrasion than the regular stone since the latter lost more weight under a lighter load after three days' time. Apparently there is no direct correlation between hardness and abrasion loss. The oil treatment generally decreases the resistance to abrasion somewhat, although more study on this phase of the problem is desirable.

Table IX compares improved and regular stones aged three days in the untreated and oil-treated conditions when abraded under loads of 250, 500, 750, and 1,000 Gm. Here again, the same behavior noted previously occurs. The specimens' weight loss is essentially proportional to the increase in weight applied. The regular stone loses more weight, and the oil treatment is of no particular benefit in decreasing abrasion loss.

CONCLUSIONS

1. A comparison of the hardness of the regular stones examined indicates that the values are similar. This is also true for the improved stones. The latter are appreciably harder than the regular stones.
2. The improved stones attain their maximum hardness in a shorter time interval than do the regular stones; three days seems to be optimum for the improved stones.
3. Neither oil nor water immersion treatments improve the hardness of the dental stones investigated.
4. The dry crushing strengths are greater than the wet crushing strengths.
5. The crushing strengths of the improved stones are similar, as are those of the regular stones, but the improved stones have appreciably higher values than do the regular ones.
6. Oil and water immersion treatments definitely decrease the crushing strengths of the dental stones investigated.
7. Improved stones are more resistant to abrasion than are regular stones.
8. The weight loss due to abrasion decreases with aging time up to one week, the longest time tested.
9. Oil treatment does not improve the resistance of the stones to abrasion.

10. Abrasion loss increases in an approximately linear fashion as the load on the specimen of improved stone is increased.

11. Centrifuging increases the hardness for early periods after setting, but does not influence the long time values.

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University of Michigan
School of Dentistry
Ann Arbor, Mich.

FACTORS AFFECTING THE SURFACE OF STONE DIES POURED IN HYDROCOLLOID IMPRESSIONS

RALPH W. PHILLIPS, B.S., AND BEN Y. ITO

School of Dentistry, Indiana University, Indianapolis, Ind.

ALTHOUGH many investigators have studied the physical properties of plaster and stone as they are influenced by manipulative variables,[1-3] no research has been reported on the factors which affect the surface condition of stone casts poured into hydrocolloid impressions. Various types of die materials have been employed by dentists since Sears introduced the reversible hydrocolloid technique for indirect restorations.[4] One of the obstacles to the success of the procedure has been the lack of a hard, yet accurate, die material, and it was not until the introduction of the newer type hydrocals that this problem was eliminated.[5] If care is used, these stones offer a hard surface upon which the wax pattern can be safely fabricated.

Many factors, however, influence the surface condition present on these dies. Any chalkiness, roughness, irregularities, or presence of bubbles can be a constant source of discouragement and error, particularly when such imperfections occur on the margins. Reversible hydrocolloid will reproduce the sharpest of detail, but this accuracy can be carried on to the actual working die only if the stone surface is smooth, dense, and hard. Thus one of the daily problems confronting the user of hydrocolloid is the necessity of routinely securing a satisfactory surface on the stone die. The ability to accomplish this is dependent upon establishing a simple, yet standardized, procedure. Certain variables that affect the texture of the surface have long been recognized, yet others have not been given serious thought. It was the purpose of this investigation to evaluate carefully the various factors which do influence the surface condition.

PROCEDURE

Unless otherwise specified, one representative commercial stone* was used throughout this study. The recommended powder-water ratio (100 Gm. to 24 c.c.) was employed, with the powder weighed on a balance and the water measured by pipette. The stone was mixed in a rubber bowl for one minute. A minimum of six dies was made for each set of conditions, and whenever the results obtained were erratic, additional dies were prepared. Photographs shown in this paper are representative of the general trend.

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*Duroc (Ransom & Randolph Company, Toledo, Ohio).

Primarily, one brand hydrocolloid* was used throughout. The boiling and storage temperatures recommended by the manufacturer were used with new material for each specimen. A mixing gun was employed. The mold was prepared by filling a metal ring, ¾ inch inside diameter and 1 inch long, with hydrocolloid. A cylindrical gold specimen, ½ inch long, was then placed in the center of the ring. One side of this cylinder, ⅜ inch wide, was flat and highly polished. It was this flat area that was studied on the subsequent stone dies. At the end of 10 minutes, the gold plug was snapped out of the impression, and the stone die was poured immediately. The ring was then placed in a humidor at 100 per cent humidity, and the stone was allowed to harden for a minimum of one hour before removal from the impression.

Fig. 1.

Fig. 2.

Fig. 1.—Apparatus used for regulating the rate of flow of stone.
Fig. 2.—Stone flowing into a mold at a constant rate.

One of the variables associated with the preparation of the stone die which had to be controlled throughout this investigation was the rate at which the stone was introduced into the mold. As will be shown later, the rate of stone flow does have an effect on the surface. To eliminate this variable, a special apparatus was designed and is shown in Fig. 1. A platform, having a receptacle for holding the ring with the hydrocolloid mold, and a funnel for pouring the

*Deelastic (Handy and Harman Co.).

stone was constructed to fit on top of the mechanical vibrator. The mixed stone was merely placed in the funnel and with a low vibration was allowed to flow down into the hydrocolloid mold, thus keeping the rate of flow of the stone constant for all specimens. In Fig. 2 the actual pouring process can be seen. With this simple apparatus, it was possible to prepare specimens mechanically in which variation due to amount of vibration and rate of flow of the stone into the mold was eliminated.

All stone dies were studied and photographed under ×7 magnification. Uniform lighting conditions were established, employing a grazing light to accentuate surface irregularities.

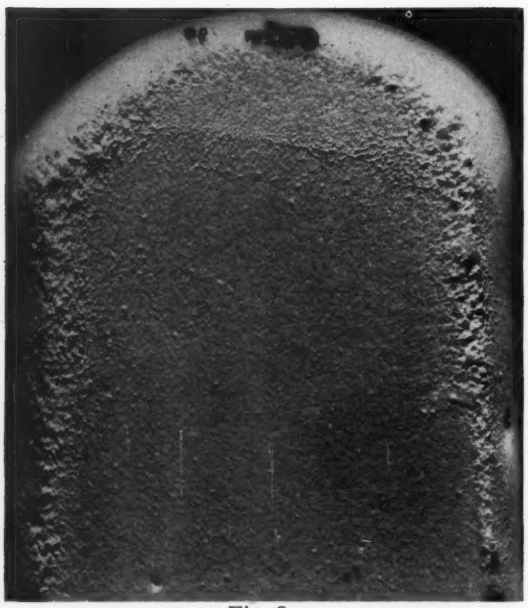

Fig. 3.

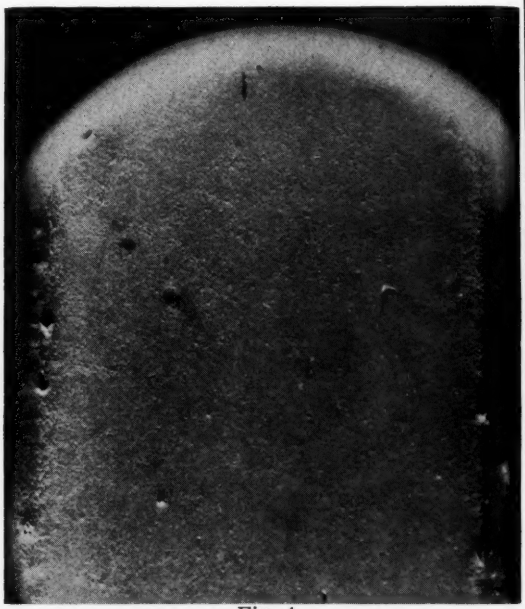

Fig. 4.

Fig. 3.—Chalkiness caused from reaction between a particular combination of hydrocolloid and stone.

Fig. 4.—Potassium sulfate immersion for 15 minutes has eliminated surface condition shown in Fig. 3.

EFFECT OF POTASSIUM SULFATE

The use of a 2 per cent potassium sulfate solution for immersing hydrocolloid impressions before pouring has long been a controversial issue. It is believed by many that such a sulfate impregnation will accelerate the set of the stone and hence improve the surface of the die. To determine whether such a treatment does have a beneficial effect, the following series of tests were made.

Dies poured in impressions which had been immersed for 15 minutes in 2 per cent potassium sulfate seemed to exhibit a slightly better surface than dies poured in impressions which had not been previously treated. However, the surfaces were so similar in appearance that it was not possible photographically to demonstrate any difference. It can merely be stated that observations on many dies did indicate a slightly denser surface on the surface of dies which

had been poured in impressions treated in potassium sulfate, but the difference noted was not clinically significant.

When other combinations of commercial hydrocolloids and stones were studied in the same manner, there were several instances where a definite deleterious effect was noted when the potassium sulfate immersion was omitted. The surface of a stone die which was poured in an impression made from a different brand hydrocolloid is shown in Fig. 3. The chalkiness is extremely severe, and would produce a totally unusable cast. The surface obtained when the same combination of materials was employed but the hydrocolloid impression was immersed in 2 per cent potassium sulfate for 15 minutes before pouring is shown in Fig. 4. The surface is now satisfactory. Thus it can be seen that, for certain combinations of hydrocolloids and stones which are not compatible, the use of potassium sulfate is definitely imperative.

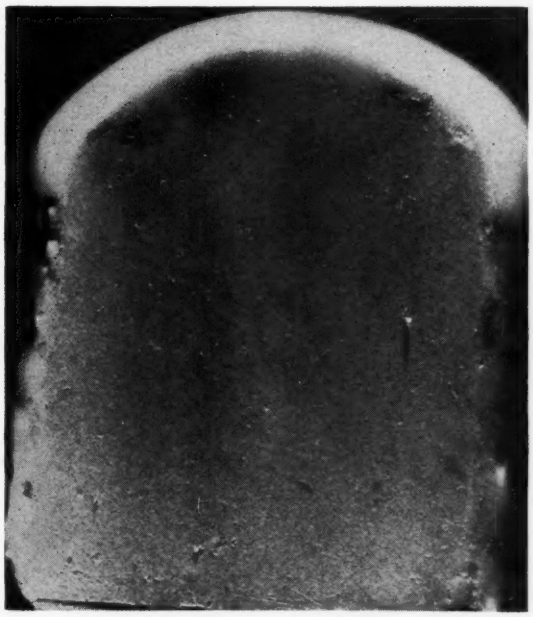

Fig. 5.—Surface of a stone specimen separated 18 hours after pouring. The impression was treated with potassium sulfate.

Further studies indicated that the use of potassium sulfate is a good safety precaution in those instances where the cast is not separated from the impression within the first few hours. It has generally been suggested that the stone die be removed from the hydrocolloid within a reasonable period of time in order to prevent any possible reaction between the two. On occasion, however, it is inconvenient to separate the die at the end of an hour. Dies poured at the end of the day are often not removed until the next morning. The surface of a die which was poured in an impression treated for 15 minutes in potassium sulfate but not separated from the impression until the end of 18 hours is shown in Fig. 5. No surface discrepancies are evidenced. However, when the impres-

sion was not first treated with potassium sulfate, upon separation at the end of 18 hours the surface was covered with small nodules and a general roughness (Fig. 6). Although this surface condition was not always reproducible, the photograph is representative of the average. Dies separated during the first few hours generally did not exhibit any such reaction.

This phenomenon is not unique to the particular brand of stone or hydrocolloid. Figs. 7, 8, and 9 illustrate the same deleterious effects when other combinations of commercial hydrocolloids and stones were used. The degree and type of surface injury varies with each combination. Apparently the use of potassium sulfate produces a more resistant stone surface which is unaffected by the subsequent synaeresis which occurs in the hydrocolloid.

Thus immersion of the impression in 2 per cent potassium sulfate for 10 to 15 minutes is advantageous in producing a slightly superior stone surface and in preventing any deleterious effect should the die not be separated from the impression within the first few hours. Actual working time is not greatly increased since this immersion can be done during the interval when the stone is being proportioned and mixed. Previous research has shown that the degree of distortion occurring in the impression during this brief immersion period is not clinically significant.[6]

MIXING SYRINGE

The use of a special gun or syringe to mix the hydrocolloid thoroughly during boiling, and preparatory to filling the tray, was an accepted procedure some years ago. At the present time, most operators prefer to boil the material in the tube and then fill the tray directly from the tube. However, Sears and Wooster[7] and others still prefer to use the mixing gun, and tests made in this investigation suggest that it is still the preferred technique.

The type of imperfection that will occasionally occur if the hydrocolloid is not mixed thoroughly during its preparation is seen in Fig 10. A chalky streak can be noted down the right side of the die. This is probably due to a concentrated area of agar or other ingredients which were not evenly distributed throughout the material. Although this type of surface irregularity is not severe and is found infrequently, it is the type of thing which can be disturbing to the careful operator, and it can be prevented by using the mixing gun.

EXCESS WATER IN IMPRESSIONS

After the 10- or 15-minute recommended immersion in 2 per cent potassium sulfate, the excess solution should be carefully blown out before the stone is poured (Fig. 11). There will be small droplets of solution remaining in the preparation and, unless they are removed, streaks or pitting may result (Fig. 12). Some operators suggest the use of a small cotton wick, but gentle use of a chip blower seems to be a somewhat safer procedure. The impression must not be dehydrated, and a wet, moist surface on the hydrocolloid should be evident. If there is an actual drying out of the impression, disastrous dimensional change will occur. Tests made in this investigation also showed that excessive drying

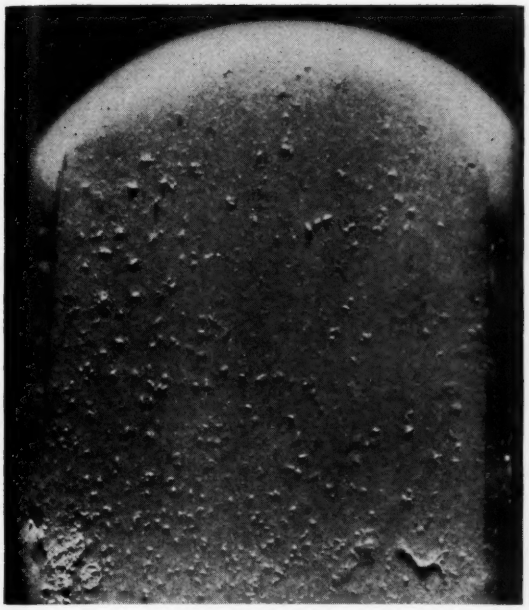

Fig. 6.

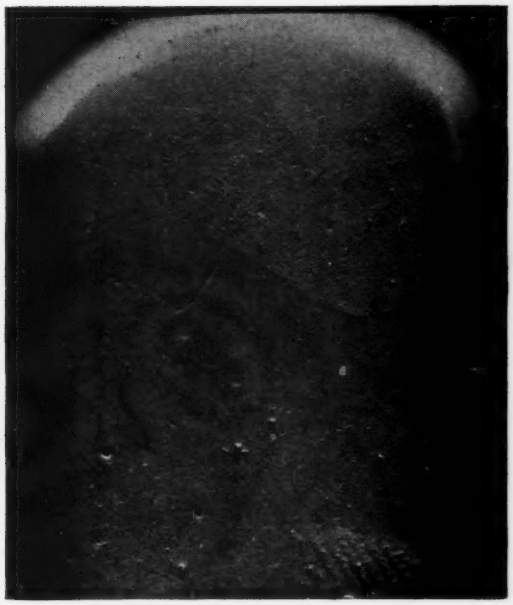

Fig. 7.

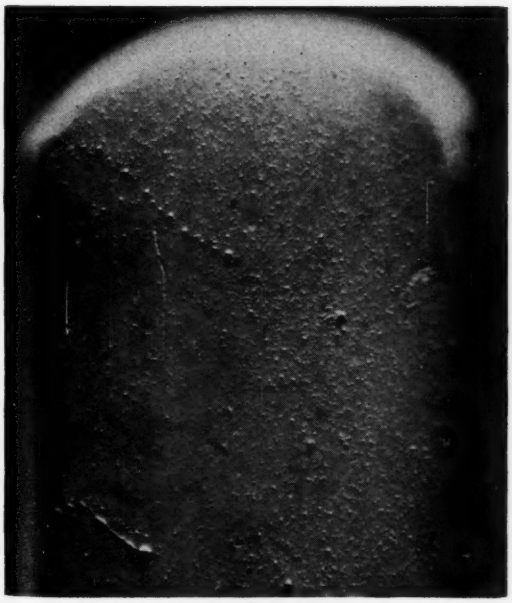

Fig. 8.

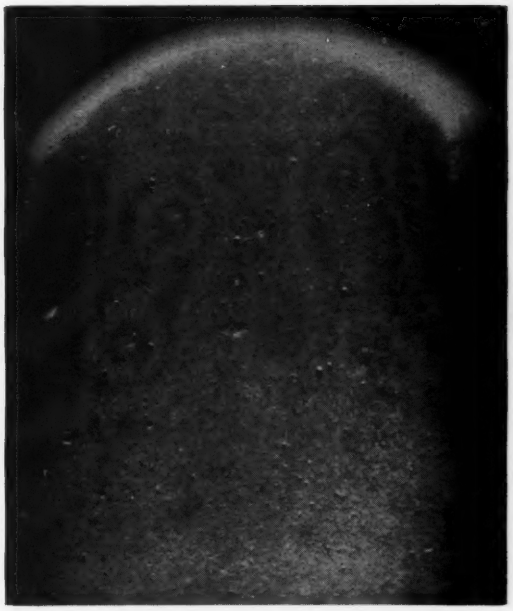

Fig. 9.

Fig. 6.—Surface of stone separated after 18 hours but the impression was not previously treated with potassium sulfate.

Figs. 7-9.—Surface imperfections on other combinations of stones and hydrocolloids which were separated at the end of 18 hours and not treated previously with potassium sulfate.

of the surface will cause the stone to stick to the hydrocolloid and leave rough areas upon separation.

Fig. 10.—Chalky streak on right side caused from not using mixing gun. This condition occurs infrequently.

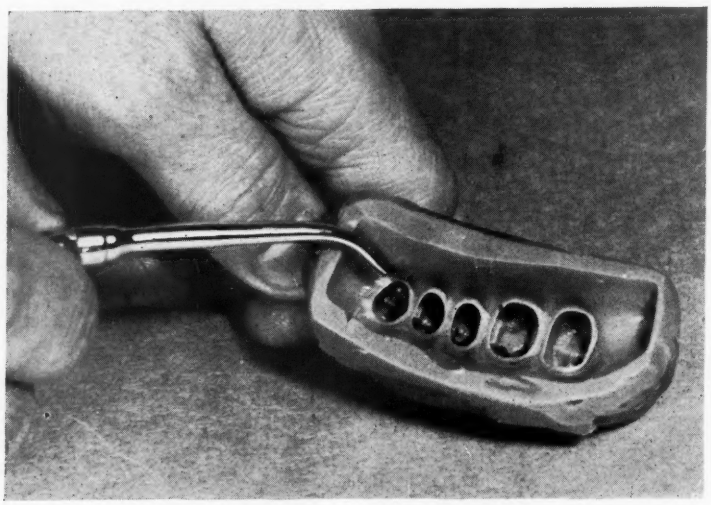

Fig. 11.—Blowing out excess water before pouring the stone.

VIBRATION AND RATE OF FLOW

As pointed out earlier, in this study special attention was given to controlling the amount of vibration and rate of stone flow in pouring the die. The use of a mechanical vibrator has been an accepted part of the hydrocolloid

technique, but no investigators have cautioned against improper control of the amount of vibration and rate of adding the stone. The surface produced when a series of tests were made in which excessive vibration was employed and the stone added in large quantities is shown in Fig. 13. Either, or both, of these variables will tend to entrap bubbles and produce the nodules shown, in greater or lesser magnitude, depending upon the actual technique. If the mechanical vibrator does not have a "low" speed, then the tray can be cushioned with a finger, thus reducing the vibration. The method of filling the mold, in which small amounts are continually added from one part of the impression, is demonstrated in Fig. 14. Unfortunately, the impression cannot be poured in a haphazard fashion.

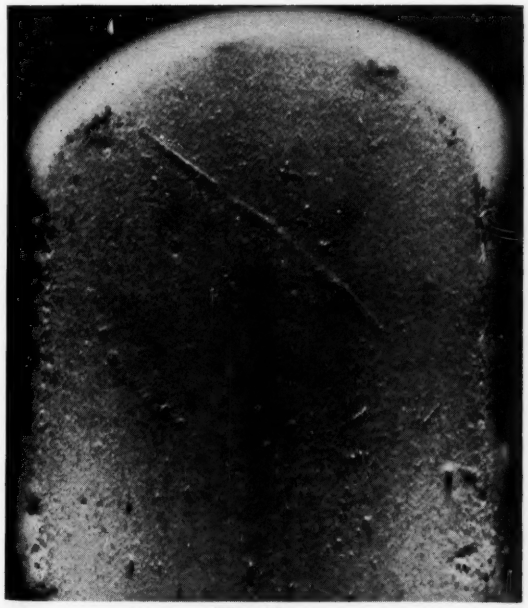

Fig. 12.

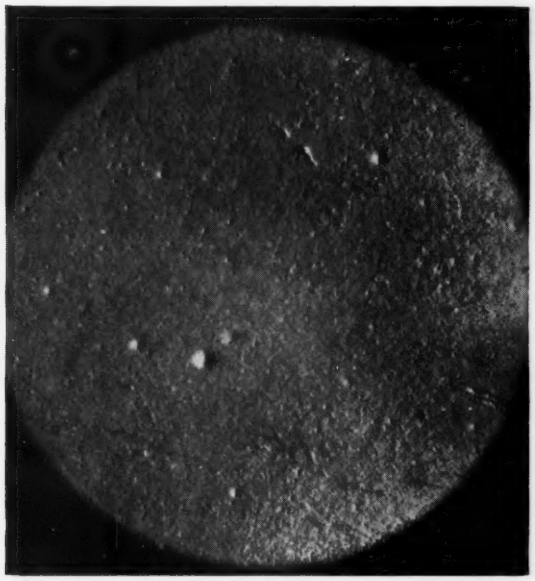

Fig. 13.

Fig. 12.—Rough surface induced by droplets remaining in the impression.

Fig. 13.—Surface nodules caused from excessive vibration and rate of flow (×17).

LENGTH OF TIME BEFORE SEPARATION

The stone die must be allowed ample time to set before separation. If the die is removed too soon, small particles of stone may adhere to the hydrocolloid, leaving a pitted surface on the cast. Such a surface where the stone was allowed to harden only 15 minutes before it was separated from the impression is shown in Fig. 15. Although the surface is not extremely porous, a much harder and denser surface was secured when the separation time was increased to 30 minutes, as evidenced in Fig. 16. Thirty minutes seems to be the minimum time and the authors feel one hour to be even better. This coincides with the practice of Sears and Wooster, Thompson, James, Mann, and others. The die should not be actually worked on for a period of 24 hours.

Fig. 14.—Stone should be added slowly, in small quantities.

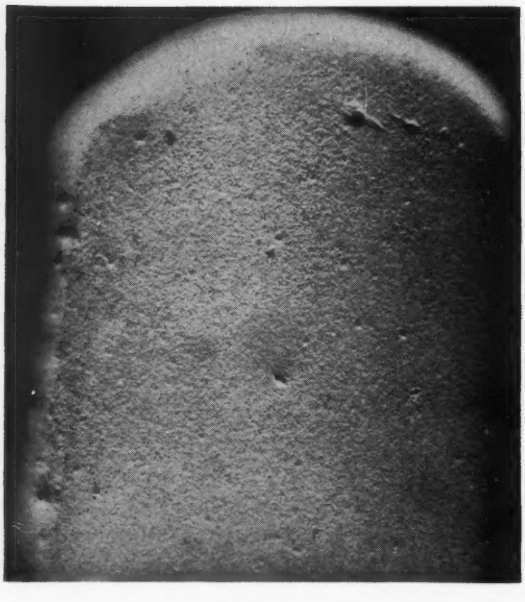

Fig. 15.

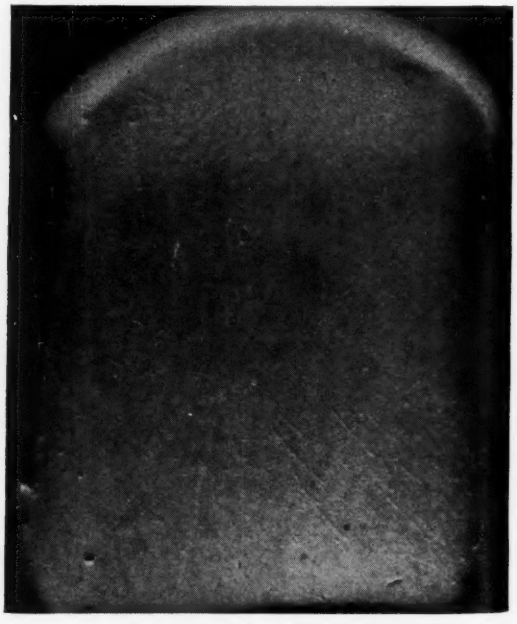

Fig. 16.

Fig. 15.—Stone die removed at end of 15 minutes.

Fig. 16.—Die allowed to harden 30 minutes before removal.

MISCELLANEOUS FACTORS

Many other variables were studied but in most instances the effects obtained were not of sufficient magnitude to record photographically. Those factors are discussed below.

Deviation from the proper water-powder ratio not only alters the setting expansion of the stone but also influences the surface density. Specimens prepared with thick or thin mixes were generally inferior to those where the recommended ratio was followed.

If the stone is mixed under vacuum, a somewhat denser surface is secured. The improvement is not great when compared with a careful hand technique, but the use of this equipment standardizes the procedure by eliminating some of the human variables. If such equipment is available in the laboratory, it should be employed for preparation of the stone.

There has long been argument relative to the media in which the poured impression should be placed while the stone is hardening. Specimens were prepared from impressions stored in tap water, 100 per cent relative humidity, air, and 2 per cent potassium sulfate solution. Careful study revealed little difference in surface condition. It was the author's feeling, however, that an edge of superiority could be given to those dies where the impression was stored in 100 per cent relative humidity during this period. Previous research has proved that distortion of the impression is also minimized in this environment, which is an important consideration if techniques are employed where two separate pours are required for each impression.[6]

CONCLUSIONS

Various factors influence the surface of stone dies poured in hydrocolloid impressions. Routine fabrication of smooth, dense casts is essential to the success of this indirect technique and can be accomplished only by adherence to a careful, standardized procedure. Although many of the variables investigated in this research did not produce marked effects on the stone surface, the final result is dependent on the sum total of all these factors.

The recommended water-powder ratio should be adhered to, and mixing the stone under vacuum is slightly beneficial. Use of a mixing gun in preparing the hydrocolloid will minimize occasional imperfections in the die. All excess water or potassium sulfate should be blown out of the mold before pouring, but excessive dehydration must be prevented. The stone should be mechanically vibrated into the impression at an even rate of flow, employing mild vibration.

Ten- or fifteen-minute immersion in 2 per cent potassium sulfate prior to pouring the die is indicated. In terms of surface density, 100 per cent relative humidity is the best environment for storing the impression while the stone is setting, and the die should be allowed to harden one hour before separation.

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1121 W. Michigan St.,
Indianapolis 2, Ind.

SURGICAL PROSTHESIS

ROBERT M. APPLEMAN, D.D.S.*

Walter G. Zoller Memorial Dental Clinic,
The University of Chicago, Chicago, Ill.

SURGICAL prosthesis may be defined as the development of any type of an appliance which will aid in the reconstruction of missing parts of the anatomy through the combined efforts of the prosthodontist and the surgeon, thereby restoring esthetics and improving function.

The early literature is replete with articles dealing with reparative surgery and dental prosthesis for the relief of facial defects and deformities arising from destructive diseases. The ancient Hindus some three thousand years ago wrote descriptions of operations for the restoration of missing parts of the face and nose. Many of these procedures are today considered good operative procedure in rhinoplasty. Ambrose Paré,[1] Pierre Fauchard,[2] Suerson,[3] Delabarre,[4] Martin,[5] Kingsley,[6] and others have written on artificial replacements of missing parts.

An increasing awareness of malignancies of various types has brought about a corresponding increase in the number of people who experience deformities resulting from surgical procedures. Surgeons who are unfamiliar with the possibilities of prosthesis have depended solely upon their own resources; as a result, in cases where destructive processes have extended to the supporting structures of the face, the methods employed have been insufficient.

We all realize fully that prosthetic restorations have their limitations; yet dentists who are unfamiliar with surgical methods of restoration use all of their ingenuity in an attempt to overcome difficulties by the use of appliances. When it is known that tissues have to be removed because of disease and must be replaced by mechanical means, the prosthodontist should be consulted before the tissues are removed.

Consultation at this time, prior to operation, offers the prosthodontist an opportunity to observe the patient and formulate a treatment plan with the surgeon. The results of such consultation would enable the surgeon, if the nature and extent of the disease permitted, to retain the parts of advantage and to remove those which at a later date would not only cause difficulty to the prosthodontist but discomfort to the patient as well. The experience gained in the two world wars has clearly demonstrated the benefits to be derived from cooperative effort between the prosthodontist and surgeon.

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*Associate professor.

Kazanjian[7] has stated that the majority of facial restorative work today is being done by general surgeons because, as a rule, oral surgeons have not essayed the treatment of complicated and extensive facial deformities. This means, of course, that most of the reconstructive surgery of the face is being done by surgeons who are often unaware of the benefits, to themselves and to the patient, which may result from close cooperation with the prosthodontist before and during operative procedures. Realization of these benefits has resulted in a new interest in the field of surgical prosthesis, the potentialities of which by no means have been fully realized.

When a plan of procedure has been agreed upon, appliances which are generally used to assist the surgeon at the time of the operation, or very shortly after it, should be considered temporary. Such restorations will need frequent observation and changes since newly acquired functions of the remaining musculature will place changing demands upon the appliance. Healing and contracture often make minor adjustments necessary. This may be illustrated well by the following case.

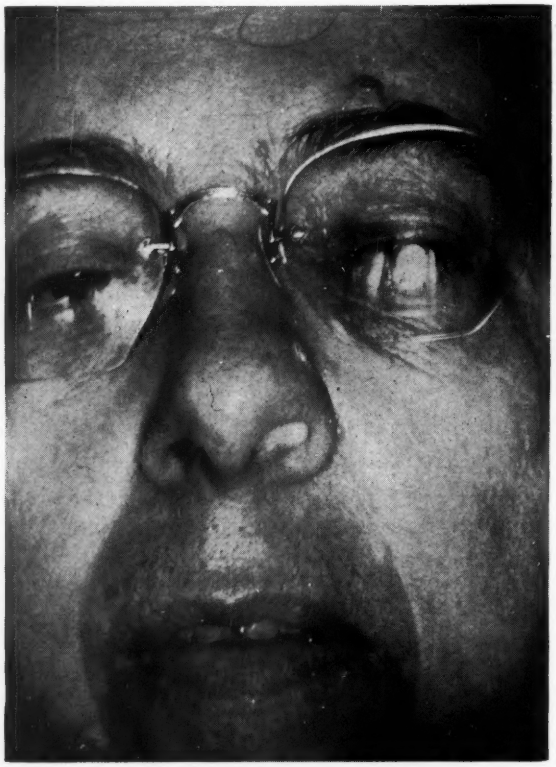

Fig. 1.—Case 1. Swelling of the left side of the face and nose.

CASE 1.—A 64-year-old white woman was first examined in the Ear, Nose and Throat Clinic on Feb. 9, 1950 (Fig. 1). She complained of a blocked nose on the left side, a stuffy left ear, and a numbness of the left side of the face. The patient had been treated surgically for nasal polyposis on several occasions over

a period of ten years. About six months prior to her initial visit, she had received fourteen deep roentgen-ray treatments with very little or no benefit. Examination revealed a large mass in the left nasal chamber. It appeared polypoid but quite vascular. The mass extended into the left nasopharnyx obstructing the left auditory tube. There was a secretory otitis media on the left side. A diffuse hyperesthesia was present over the left side of the face.

Roentgenographic examination showed erosion of the wall of the left antrum, and a clouding of the left paranasal sinuses. The histopathologic report of the biopsy was ameloblastoma. A lateral rhinotomy was performed on Feb. 20, 1950. The postoperative course was uneventful. The patient has continued to do well with no evidence of recurrence.

Fig. 2.—Case 1. The transparent appliance in position separating the oral and nasal cavities, making observation of the underlying tissues easy.

After excision of part of the maxilla and the lateral wall of the nose and exenteration of the ethmoid cells and frontal sinuses, a definite depression of the tissues of the cheek existed. In most instances, this cavity would have been packed with gauze and allowed to heal. Such a procedure, however, necessitates the frequent removal of the gauze which causes discomfort to the patient. When the gauze dressing is finally omitted, the formation of scar tissue is invited which makes the restoration of facial contour impossible. In this case, an impression of the cavity was made of modeling compound immediately following the surgery, before the patient left the operating room. In this way it was possible to manipulate the modeling compound in such a manner that the normal contour of the face was re-established. The means of removal and insertion of the modeling compound form were examined, since in most instances the inside dimensions of the deeper portion of the cavity greatly exceed that of the orifice.

The modeling compound form thus developed was duplicated in a plastic resin material. Forty-eight hours later, this form was inserted into the defect

and an impression was made which included the protruding edge of the plastic insert, as well as the teeth along that side of the arch. From the cast formed by this impression, clasps were constructed to hold the appliance in position. The communication between the oral and nasal cavities was closed off which allowed healing to progress in a normal manner (Fig. 2). The appliance prevented food from entering the cavity, and eliminated the formation of scar tissue. The clear plastic construction of the restoration facilitated easy observation of the underlying tissues. Normal facial contour was maintained and the muscles of the cheek functioned in a normal manner (Fig. 3).

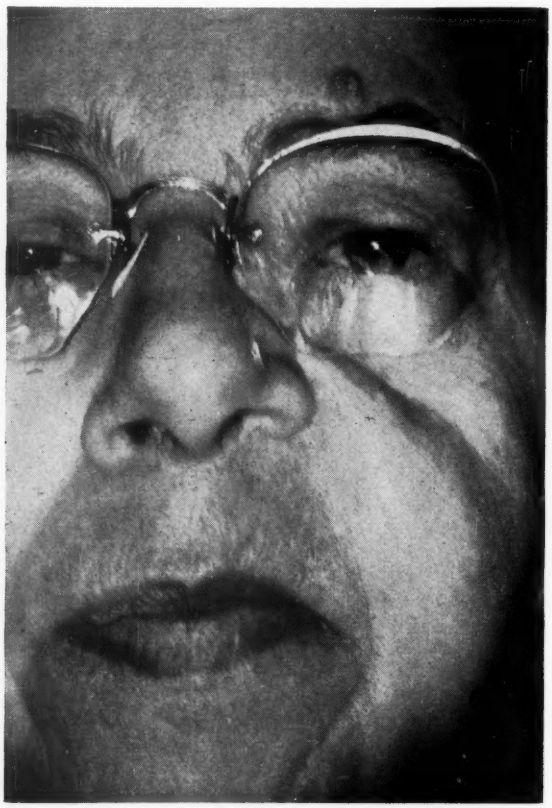

Fig. 3.—Case 1. Facial contour restored with appliance in position.

Malignancies of the maxillary sinus frequently necessitate the removal of part of the alveolar ridge and palate. The soft tissue covering this area may or may not be involved. When no involvement is noted, this tissue is sutured to the side of the cheek in an attempt to close the defect. If there is insufficient blood supply to the remaining palatal tissues, necrosis and sloughing develop, leaving a cavity which makes speech and mastication impossible.

Case 2.—A 76-year-old white man presented an adenocarcinoma of the left maxillary sinus. An attempt was made to retain the soft tissue of one-half of the

hard palate by surturing it into the cheek on that side. Because of insufficient blood supply to the area and previous radiation therapy, necrosis and sloughing necessitated the removal of that tissue. This left a cavity approximately 50 mm. long and 30 mm. wide communicating directly with the nasopharnyx. The turbinate bones were exposed; mastication and speech were impossible, and susceptibility to infection was greatly increased (Fig. 4).

Roentgenograms of the remaining teeth on the right side of the maxilla disclosed poor bony support, making the teeth useless for retentive purposes. They were, however, retained since there was no evidence of foci of infection, and the patient refused further surgery. The thickness and character of the remaining palatal tissue were carefully examined to determine the amount of relief which could be made in the subsequent modeling compound impression. The vestibule area, from the right central incisor to the tuberosity on that side, revealed an undercut region which was used for additional retention of the appliance.

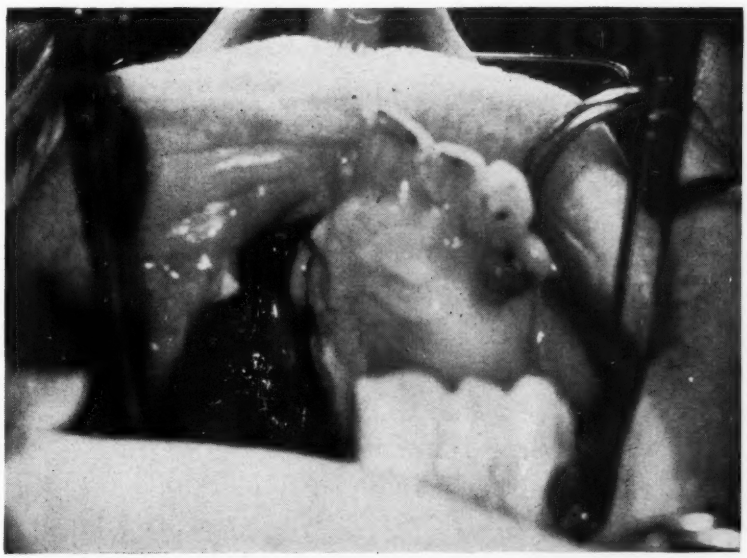

Fig. 4.—Case 2. Cavity created by removal of palatal tissue communicating with the nasopharnyx (this is being observed in a mirror).

A full upper impression was made of well-softened modeling compound, allowing the material to freely enter the defect. Upon removal and chilling, the entire palatal surface was relieved approximately 1 mm. and cotton fibers were embedded in it. Using the prepared modeling compound as a tray, an accurate impression of the cavity was made with an alginate material. A bulb which fitted the defect in the palate was constructed of clear plastic material. This was accurately positioned in the cavity.

The alginate material was removed from the compound tray. In the area of the defect, the modeling compound was removed to such an extent that the tray could be seated into the mouth without any impingement upon the edges of the positioned bulb. Cotton fibers were again attached to the surface of the modeling compound, and a new impression was made with the alginate material.

Particular attention was given to the buccal vestibule area above the remaining teeth. A minimum amount of pressure was allowed to be exerted upon the positioned bulb.

A resin denture base was constructed which covered all of the base area to be involved in the finished denture. The lingual surface of the peripheral border on the right side was packed with soft acrylic resin, so that the denture might be inserted into the undercut areas in that region. The tissue side of the resin base contained an impression of the edge of the bulb which was channeled out to allow space for autopolymerizing resin. This type of material was used to minimize distortion and warpage when the bulb was attached to the processed denture base. Occlusion rims were formed, and centric relation was recorded. The artificial teeth were grooved and stained to more nearly resemble the remaining natural teeth. A try-in was made to check the esthetics and jaw relationship. Processing the finished denture was accomplished in the same manner as was the sealing of the bulb to the palatal portion of the appliance. When positioned in the mouth the finished denture completely separated the oral and nasal cavities, making speech and mastication again possible (Fig. 5).

Fig. 5.—Case 2. Cavity completely closed off by placing the prosthesis.

I have described two cases, one in which practically all of the teeth were present, and the other in which only a portion of the natural teeth remained.

The edentulous patient presents a problem of a somewhat different nature. First, there is no longer any bony support under a portion of the palatal surface of the denture base. This makes stabilization of a full upper denture impossible. Second, if closure of the defect is completed by suturing the palatal tissue into the cheek, the loss of the buccal sulcus area, and the newly acquired function of the buccinator and masseter muscles on the affected side definitely impair retention. Third, in many instances, union of the palatal tissues and cheek may be incomplete, allowing a direct communication with an external opening. When this occurs a negative pressure is established making retention of the denture base almost impossible.

The impression technique is the same as described above, although more attention is given to muscle trimming and to the region of the defective area. If at all possible, undercut areas in the region of the defect should be utilized. Care and judgment must always be exercised in this practice, for undue pressure in this region may easily destroy the desired results.

CASE 3.—A 51-year-old white woman complained of pain and swelling in the right cheek. Clinical examination revealed a lesion in the canine fossa extending distal to the region of the second bicuspid in the mucobuccal fold (Fig. 6).

Fig. 6.—Case 3. Preoperative photograph of patient showing a slight swelling on the right side.

Biopsy of this region revealed an intermediate neoplasm. A lateral rhinotomy incision was made, extending around the border of the nose and through the upper lip. An incision was then made through the mucosa deep in the labial and buccal sulcus from the midline to the tuberosity. The facial flap was then reflected away from the face of the maxilla, leaving some connective tissue and fat on the anterior surface. The tumor mass was seen to be eroding through the anterior wall of the maxilla and was attached to the zygoma. The nasal bones were separated at the midline, and the frontal process of the maxilla and nasal bones were severed. A mucoperiosteal flap of the palate was reflected downward and the palate separated in the midline. The maxillary tuberosity was separated from the pterygoid process and it was found necessary to extend a horizontal incision underneath the right eye to

give adequate exposure to the arch of the zygoma. The arch was cut and the frontal process of the zygoma was severed. The entire block of zygoma and maxilla was mobilized and lifted out of the base without any difficulty (Fig. 7). The tissue was sutured in position, and the cavity was packed with gauze. This was allowed to remain for six days, at which time the patient was again given a general anesthetic, the gauze was removed, and an impression was made of the remaining portion of the maxilla and defect. Because of the difficulty in getting the mouth open wide enough to make an impression without splitting the incision in the lip, modeling compound was molded over the remaining portion of the maxilla and into the defective area. A template and an attached hollow bulb was constructed from the resultant cast and placed into the patient's mouth. This was used for a period of two weeks at which time the patient had exercised her jaws sufficiently to permit the introduction of a standard edentulous tray. At this time, impressions of both upper and lower jaws were obtained, and full upper and lower dentures were constructed. This patient is progressing nicely; speech is normal; mastication is satisfactory, and appearance is fair. Further surgery will be undertaken at a later date to correct the deformity caused by the removal of the zygoma (Fig. 8).

Permanent appliances, and I use that word with reservations for I fully realize that nothing is ever permanent when one is dealing with health and tissues, are those appliances generally constructed to correct congenital defects or to replace external tissue which has been lost either by injury, disease, or surgery. The surgical reconstruction of some missing parts is quite feasible, but it requires several plastic operations over a number of months, and the ultimate benefits to the patient are little if any better than those offered by prosthesis. In this group may be listed ears, nose, eyes, parts of the face, or a combination of these.

CASE 4.—A 61-year-old white man entered the hospital with a swelling of the left side of the face and eye. A diagnosis of carcinoma of the maxillar sinus was made. A block of tissue including the entire maxilla on the left side, the zygoma, the pterygoid process, part of the lateral pterygoid muscles, the eye, a part of the ethmoid cells, the entire lateral wall of the nose, and one-half of the bony hard palate were removed (Fig. 9).

The necessity of wearing a bandage over the face at all times became a psychologic problem, and a prosthesis was constructed to replace the missing eye and a portion of the face. This was accomplished by painting a hydrocolloid material over the entire surface of the face to a thickness of approximately one-quarter of an inch. Wire mesh, for reinforcement of the hydrocolloid, was incorporated into the outer surface as the material began to solidify. Iced towels were placed over the surface of the hydrocolloid until the patient could feel the penetration of cold through the hydrocolloid. Strips of gauze, impregnated with plaster of Paris, were placed over the surface of the hydrocolloid, and a core of plaster one-half inch in thickness was added. Extreme care was exercised to allow the nostrils to remain open. The heat generated by the setting of the plaster had no effect upon the hydrocolloid material. When the plaster of Paris

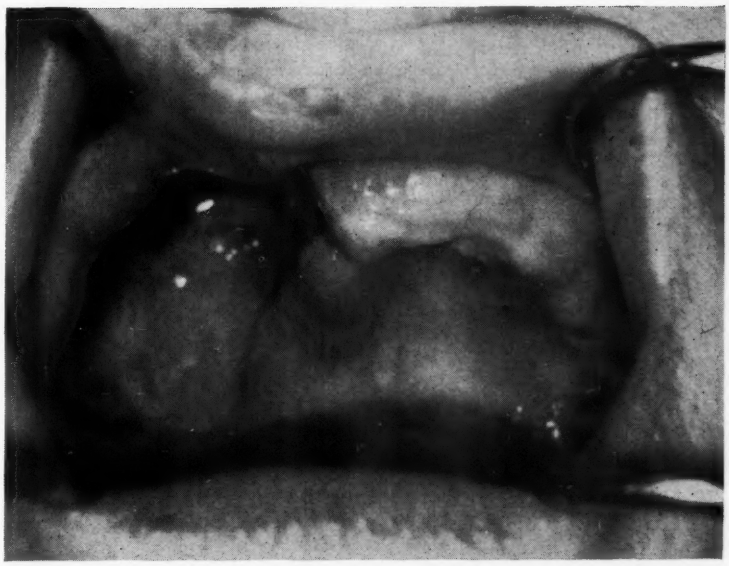

Fig. 7.—Case 3. The healed cavity following the removal of the neoplasm

Fig. 8.—Case 3. Postoperative photograph with dentures in position. Further surgery will correct the lost zygoma.

had completely set, the patient was asked to move the muscles of the face much in the same manner as one would when shaving. This action loosened the impression and removal was easily accomplished. The impression was filled immediately with artificial stone. This produced an accurate reproduction of the defect and the remaining part of the face. Baseplate wax was used to fill the cavity. It was carved to correspond with the remaining normal side of the face. A glass artificial eye was selected to match the normal eye. This was tin-foiled on the posterior surface, and placed in position in the wax mold. The wax form was removed from the cast and placed upon the patient's face. Minor corrections were made at this time. The location of the artificial eye in relation to the normal one was carefully checked, and measurements taken for glasses.

Fig. 9.—Case 4. Loss of the eye and part of the face creates a psychologic problem.

A split two-piece mold was made by placing the wax form back on the cast, coating the external surface of the cast with a separating medium, and boxing in the entire cast. This was filled by vibrating plaster of Paris into the area to a thickness of approximately 3 inches. The wax was removed in much the same manner as it would be done in the construction of full dentures. Foiling of the artificial eye was then completed, and it was cemented into position. Two one-quarter inch holes were bored through the bottom half of the mold at opposite sides of the cast to gain access to the cavity. Through one of these openings Elastomere, a heavy, viscous, opaque substance, was injected. As the material reached the top of the second opening, the mold was securely tied together with cord and allowed to set for a period of thirty minutes. This allowed the material to completely settle and displace any air which might have been trapped in the process of injecting the Elastomere. The mold was then placed in an

electric oven which maintained a constant temperature of 100° C. It was allowed to remain in this temperature for a period of six hours. After bench cooling, the restoration was removed from the mold and cleaned by brushing in soapy water. The sprues were removed and the appliance placed upon the patient's face. Eye brows and lashes may be placed in the prosthesis by threading hair, which has been doubled, through a hypodermic needle, inserting the needle into the desired location, allowing the hair to remain when the needle is withdrawn. When a sufficient number of hairs have been so placed, trimming and brushing will position them correctly.

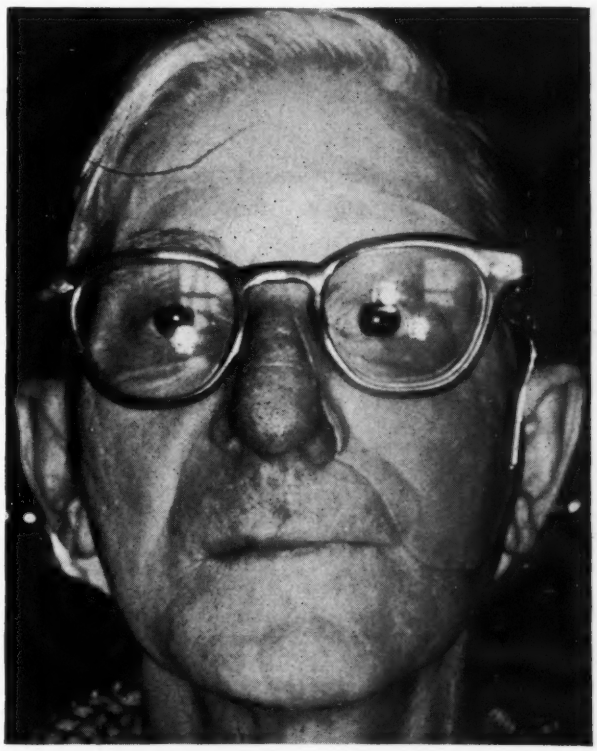

Fig. 10.—Case 4. Prosthetic replacement rehabilitates this patient.

Retention of appliances of this nature may be obtained by glueing the peripheral borders with some substance, such as masking tape or gum mastic. In many instances, these materials cause irritation to the tissues and other forms must be devised. In this case, eye glasses were used. Two gold wire springs were extended from the temple on the left side. These, in conjunction with a close adaption of the nosepiece, held the replacement in position satisfactorily (Fig. 10).

Any specific materials mentioned are those which I have found most useful in my hands, but I do not wish to convey the impression that they are the only ones suitable or available. Gelatin, latex rubber and soft acrylic have all been

used for these restorations. Elastomere is a rubberlike substance which is obtained in the liquid form. It may be colored by mixing oil-soluble dyes into the material. When processed, tinting the restoration with the same type of dye will add materially to the finished prosthesis. It does not harden with age and retains its color most satisfactorily.

I believe it is perfectly clear that the physiology involved in the adaptation of appliances for these individuals is vastly different from that experienced in the placement of the average full upper and lower denture. When the musculature, glands, and other tissues have been disturbed by surgical intervention, considerably more time, patience, and effort are necessary to obtain a normal function. These prostheses must be so designed that the remaining anatomic parts may have the opportunity of developing a functional relationship with the appliance. It is a great satisfaction to see how quickly this adjustment can be made.

Cooperative effort between the prosthodontist and surgeon combined with a kind and sympathetic understanding with the patient leads to an early rehabilitation of these unfortunate individuals.

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Walter G. Zoller Memorial Dental Clinic
The University of Chicago
Chicago 37, Ill.

SPEECH AND CLEFT PALATE PARTIAL DENTURE PROSTHESIS

DANIEL B. TORN, D.D.S.†

Jacksonville, Fla.

THE first duty of man is to speak, that is his first business in this world (Robert Louis Stevenson). As far as we know there is no race of man that cannot talk. It is the most continuous, universal, and outstanding occupation of mankind. Speech is a function of human life. It is through speech that personality develops. All that one might learn and the character that one might build would be of no value, should it not be possible to intelligibly express the same by speech. Understandable speech is necessary in the pursuit of anything one desires for happiness.

CLEFT PALATE SPEECH

Cleft palate speech is a form of nasal speech, deficient in resonance and articulation, due to an abnormal form and size of the true resonators. For practical purposes we may regard as resonators only the cavities of the mouth and pharynx. In the oral cavity of the cleft palate patient there is a lack of union of the soft palate; or soft palate and part of the hard palate; or soft palate and hard palate extending to the alveolar ridge; or soft palate, hard palate and across the alveolar ridge. The latter involving the alveolar ridge may be unilateral with a single cleft lip and bilateral with a double cleft lip.

The pharynx normally is approximately five inches in length and consists of three parts: the nasopharynx (nasal or upper part), oropharynx (a part opposite the mouth, the only part visible on looking into the mouth), and laryngopharynx (a lower part behind the larynx). The pharynx is lined with mucous membrane, and its wall consists of constrictor muscles. Other muscles connect the pharynx with the base of the skull, with the soft palate, and with other structures. Outside of the muscular layer is a firm envelope of fibrous tissue. The cavity of the pharynx is capable of changes in size and shape during speech, and this is constantly taking place with great rapidity. The important components of the articulatory apparatus are the tongue, the lips, and the soft palate. Articulation is effected by the movement and the changes in position of the highly mobile parts in relation to the fixed parts, such as the hard palate, the teeth, the wall of the mouth, and the pharynx. Movements of the mandible exercise a great influence upon articulation. The soft palate is concerned in the articulation of all sounds which demand closure of the nasopharynx for their production.

This paper would have been read at the Palm Beach meeting of the Florida State Dental Society in November, 1949. The untimely death of Dr. Torn prevented its presentation.—Ed.

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(1) Since the cleft palate individual is not capable of producing closure of the nasopharynx, nasality in speech exists.

METHODS OF TREATMENT

There are only two forms of treatment for establishing normal resonance and articulation for the cleft palate patient:

1. Surgical treatment.
2. Prosthetic treatment.

Should surgery be selected as the method of choice, it should be well planned and performed early in life for optimum results. A mere closure of the cleft is not sufficient. An effort should be made to secure a mobile palate of sufficient length to perform the function of closing the nasopharynx for the production of intelligible speech. The surgical treatment will not be discussed further, since this article will involve, in the main, the prosthetic treatment. The prosthetic treatment consists of the construction of a functional speech appliance.

It may appear presumptuous, but it is nonetheless true, to say prosthesis is not necessarily a method of second choice; it is one of several methods, equally deserving of consideration and study. It is eminently unfair to the patient to deny him the right to *all* avenues of help. Unfortunately, it is still regarded as a dictum that prosthesis should be employed *only* if surgery has failed. Unbiased clinical experience does not support this view. It is a sobering observation that surgery is irreversible. (2) It is mainly on account of defective speech that the prosthodontist is consulted in cases of cleft palate. If it were possible to restore all the missing tissue surgically so that normal speech would result, the surgical procedures would be the method of choice. When surgery alone does not offer the patient the desired results, then the surgeon and the prosthodontist should cooperate to the fullest extent in considering the health and comfort of the patient. (3) The most impressive results that have been obtained in cases of cleft palate through prosthodontia have been those in which the cleft has been undisturbed by surgery. In such cases the aid can be designed for adaptation to structures in their more usual position, and the natural movements of the remnants of the velum and of the surrounding musculature of the pharynx can be brought into the most effective functional relationship with the periphery of the bulb and of the carrier extension or tailpiece. The prosthodontist can well be proud of the speech recovery achieved by these patients. In the surgically undisturbed case the full benefit of the prosthetic approach may be realized.

(4) Cleft palate prosthesis is a highly specialized field of dentistry requiring the skill of the prosthodontist. Since cleft palate prosthesis involves the adjacent areas to the oral cavity, the prosthodontist has had to acquire knowledge of the normal as well as of the cleft palate anatomy and physiology of these areas which control the mechanism of speech. Speech appliances are constructed for the unoperative and the operative cleft palate individual.

Unoperative patients are those for whom surgery is contraindicated due to the health and age of the patient and because the remaining tissues are insufficient for bridging the cleft.

Operative patients are those in whom the postsurgical result may be satisfactory, as in an irregular or a foreshortened soft palate which is inadequate for velar-pharyngeal closure.

EXAMINATION AND DIAGNOSIS

A complete cleft palate history should include:

1. Condition of the deformity
   a. Oral cavity
   b. Lip
   c. Nose
   d. Speech (recording of defective speech)
   e. Hearing
2. Occlusion
3. Condition of periodontal tissues and teeth
4. Tonsils
5. Intraoral and occlusal radiographs
6. Teeth tested for vitality
7. Maxillary and mandibular impressions for study casts

The maxillary impression should include the soft palate and the oropharynx. The resulting casts are mounted on an articulator with the teeth in centric relationship.

The roentgenograms will show: (1) cavities in teeth; (2) condition of the periapical and periodontal areas; (3) unerupted, impacted, and supernumerary teeth (if any); (4) cleft; (5) pathologic lesions.

On completion of the examination, the patient is referred to a physician for a basic medical examination and to a speech therapist for examination.

Recommendations

1. All cavities in teeth be filled.

2. Pulpless and periapically infected teeth be extracted. Periodontal involved area be treated. Teeth not responding, or too far advanced for periodontal treatment, be extracted.

3. Unerupted teeth be brought into occlusion when possible. Impacted teeth with infected overlying tissue and those with overlying tissue which may be subjected to a breakdown and become infected upon wearing an appliance be surgically removed.

4. Supernumerary teeth in line of the cleft be surgically removed.

5. Bone areas interfering with the path of insertion and occlusion of appliance be surgically treated.

THE SPEECH APPLIANCE

A speech appliance is a partial denture plus a palatal extension which acts as a carrier for the artificial velum. The partial denture should be so designed to give the maximum bracing, support, and retention. It should be constructed of a material of greatest strength, toughness, and resiliency, and yet light enough for comfort. Many cleft palate patients present an underdeveloped maxilla with malocclusion and often with mandibular protrusion which requires a new maxillary and mandibular relationship for the establishment of functional occlusion. This necessitates the opening of the vertical dimension and the formation of a new maxillary arch with inlays in the premolar and molar regions, also the attaching of artificial teeth to the partial denture extending labially over the natural anterior teeth, occlusally and bucally on the posteriors, or onlays on the bicuspids and molars of the partial denture. Provision is made in the denture for the covering of the unoperative or the operative hard palate defects. The palatal extension, which acts as a carrier for the attachment of the artificial velar portion, is included in the partial denture construction. The artificial velum is molded to the palatal extension and should be of sufficient size and length so that it can come in contact with the posterior pharyngeal wall a little below Passavant's cushion when apposed during speech. In repose the contact distance should be about 7 mm. The lateral surfaces of the remaining soft palate grip the molded velum during speech. In this manner an effective nasopharyngeal closure can be established for normal speech.

INSTRUCTIONS

Upon inserting the completed speech aid, the prosthodontist should explain to the patient what the appliance is supposed to do and how it should fit. This can be best done by giving the patient a mirror so that he can see for himself. Instructions should be given as to the care of the teeth in the oral cavity and the appliance. The importance of a clean mouth and appliance cannot be overstressed. At first daily inspection may be necessary in order to accomplish the desired cleanliness and at the same time care for complaints and adjustments. A recording of the speech should be made when the patient becomes fully accustomed to the appliance.

SPEECH TRAINING

The speech therapist plays an important role in the rehabilitation of the cleft palate individual. It is only through a speech training program that the patient can understand how to use the speech appliance as an instrument for acquiring normal speech. The rapidity of improvement will depend upon the accuracy of the appliance, the competency of the speech therapist, and the intelligence and the cooperation of the patient.

CONCLUSION

The prosthodontist has contributed much to the development of partial denture construction and to mankind by replacing the missing dental organs necessary for mastication and esthetics. He has furthered his contribution by securing the knowledge of the palatal sections of the oral and pharyngeal cavities and in the development of the speech appliance, which is an aid for the cleft palate patient for the production of normal speech. The results have been most gratifying by the prosthetic method of treatment and can be best appreciated by the rehabilitated cleft palate individual, who has had an unbelievable improvement in speech, personality, and health. This has afforded him a normal life and happiness in this world.

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CASE REPORT OF CONGENITAL ECTODERMAL DYSPLASIA AND REHABILITATION WITH DENTURE PROSTHESIS. I.

S. G. Applegate, D.D.S. and B. S. Savara, B.D.S. (Pb), L.D.S., R.C.S. (Eng.)*

University of Detroit, School of Dentistry, Detroit, Mich.

THE EFFECT of pituitary deficiency and congenital ectodermal defect with secondary thyroid deficiency and the problem of rehabilitation of the patient is well illustrated by the following case.

R. K., a 16-year-old boy, was seen at the University of Detroit, School of Dentistry, Oct. 10, 1947, referred for dental care from the Children's Hospital of Michigan. Since he was becoming very self-conscious due to his dental condition and was falling back in his class at school rather than maintaining his scholastic standard or showing progress, the need for dental prosthesis was felt acutely. Even in his home environment he exhibited extreme shyness, to such a degree that when forced to converse he would turn his face sideward.

PHYSICAL EXAMINATION

This 16-year-old boy had rather small, although symmetrical, features for his age. His height was 61 inches, which is 6 inches below average for his age group. His weight was 96 pounds against an average of one hundred and thirty-six pounds. The facial expression was that of an infant; the lips were prominent and protuberant (Figs. 1 and 2). The scalp hair was yellowish in color and quite thin, decreased and became lanugo type toward the neck. The eyebrows were conspicuously thin, especially in the lateral two-thirds, and the cilia of the lids were scanty. There was a slight amount of dark pigmentation of the skin around both eyes. The bridge of the nose was slightly saddle-shaped and the nares were large. The external ears were normal in shape but were prominent, and the skin covering them was very shiny. In general, the skin was smooth, relatively thin, but excessively dry. Eczema was manifested on the forearms and the thumbs. Scaling of the skin was present on both the finger tips and palms; the nails were somewhat abnormal in contour and texture. The patient's response to conversation was noticeably limited and reserved. There was a retiring indifference to his surroundings.

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*Special student, University of Detroit, School of Dentistry.

ORAL EXAMINATION

The patient had eight teeth in all: two central incisors and two cuspids in the maxilla, two cuspids and two first molars in the mandible, all of which were conical in shape, with defective and pitted enamel which predisposed to carious lesions. There was no occlusal or proximal contact of any of the teeth. The lower molars almost contacted the maxilla when the mouth was closed. The size of the mandible appeared to be normal, as compared to his stature, but had a knife-edge ridge. The palate was well developed but flattened. The tongue appeared to be abnormally large.

Radiographic examination revealed well-formed roots of the erupted teeth and the absence of any other teeth or tooth buds in either arch. All the teeth present were carious (Fig. 3).

Fig. 1.

Fig. 2.

DEVELOPMENTAL AND PREVIOUS HISTORY*

The infant was delivered by instrumentation, weighing 6¼ pounds. He required awakening for feedings; he was breast fed for five months, then placed on a formula of milk and corn syrup. The first tooth erupted at 13 months; the infant started walking at 15 months and talking at 20 months. Five deciduous teeth erupted fully, and between the ages of 7 and 10 a total of eight permanent teeth came into position.

In infancy, the child contracted measles; tonsils and adenoids were removed at 15 months. He has had an intermittent unilateral mastoid involvement, and was operated on at 9 and 15 months. He had pneumonia at 8 years. He did not perspire until 10 years of age and, until that time, was prone to listlessness

*Data furnished by Glandular Clinic of Detroit Public Schools.

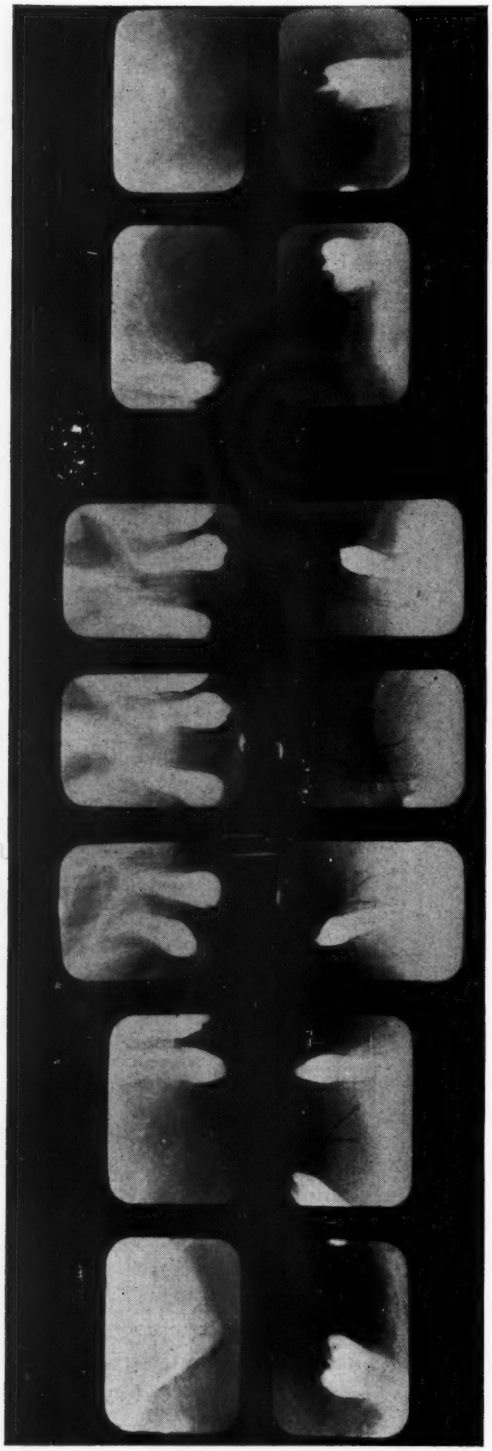

Fig. 3.

and to developing high temperatures, ranging up to 105° F. Frequent immersion of the boy in cold water was necessary to relieve these conditions. He also exhibited eczema under the knees and on the forearms.

Fig. 4.

At the age of 8½ years he was referred to the Glandular Clinic of the Detroit Public Schools (Fig. 4). He was found to be 4 inches under average height, markedly undersized, with the appearance of a "little old man." He had thin coarse hair, many missing teeth, and a thyroid gland which was small with the absence of the pyramidal lobe. His body proportions were slender and symmetrical; the hands were infantile in shape, and the skin exhibited a rough, shiny texture. Radiographic examination revealed eight permanent teeth in the mandible and the maxilla which were as yet in the developmental stage. At

this time the patient had four deciduous teeth in the maxilla and one in the mandible. Radiograms of the bone centers were correlative to the patient's age and revealed no erosion of the sella turcica, which gave the impression of being small in size.

Blood tests were negative and the basal metabolism was —6.2. The condition was diagnosed as pituitary deficiency and congenital ectodermal defect with secondary thyroid deficiency. The patient is still under treatment with regular administration of thyroid extract. Satisfactory improvement in his general condition and stature has resulted; genital development occurred spontaneously and normally. The remainder of the teeth present in the arches erupted uneventfully. Sweat glands which had been inactive up to the age of 10 years, resulting in high body temperatures during summer months, began functioning scantily in the axillae and on the soles of the feet after one and one-half years of thyroid administration. At the present time the temperature does not exceed the normal.

FAMILY HISTORY

R. K. is the third of five children and was delivered by instrumentation after the mother had been in labor thirteen hours.

His father, apparently normal, had all his teeth extracted at the age of 25 years.

The mother, showing definite signs of hypothyroidism, gives a history of fatigue, sleepiness, nervousness, irritability, and fainting attacks during pregnancy.

The first child was a boy who died at the age of 22 months due to pneumonia. No teeth had erupted; consequently no radiograms or further data are available.

The second child is a girl, now 17 years old. Her upper lateral incisors are congenitally missing, although the eruption of the other teeth was normal in all respects.

The fourth child, also a girl, is now 12 years old and has all her teeth, the eruption starting at the age of 6 months.

The fifth child, a boy, now 5 years old, had his first tooth erupt at the age of 12 months. He now has only four erupted teeth, which are conical in shape, all situated in the maxilla (Fig. 5). At the present time there is evidence of a mastoid involvement. His hair is yellowish and rather thin; his features closely resembling those of R. K. (Fig. 6).

DENTAL TREATMENT

The plan for treatment was outlined by the Prosthetic Division after careful study of the findings as secured from clinical and radiographic examinations and a survey of articulated study casts. Full consideration was also given to general health and psychologic factors involved in the case.

All the remaining natural teeth were of poor quality, contour, position, and condition, thus eliminating any possibility of the use of fixed restorations. The mandibular denture-supporting area was of such a character as to be questionable for successful complete denture prosthesis. After consideration of all the factors involved, it was deemed advisable to resort to a partial denture restoration,

if any suitable teeth could be retained and restored, rather than going to the extreme of a complete denture restoration. Therefore, most of the permanent teeth were extracted. The mandibular cuspids, though conical in shape, were retained. While extracting the upper anterior teeth, care was taken not to remove any bone. At the same time, the muscle attachments in the mandibular anterior region were lowered. The two lower cuspids were recontoured with

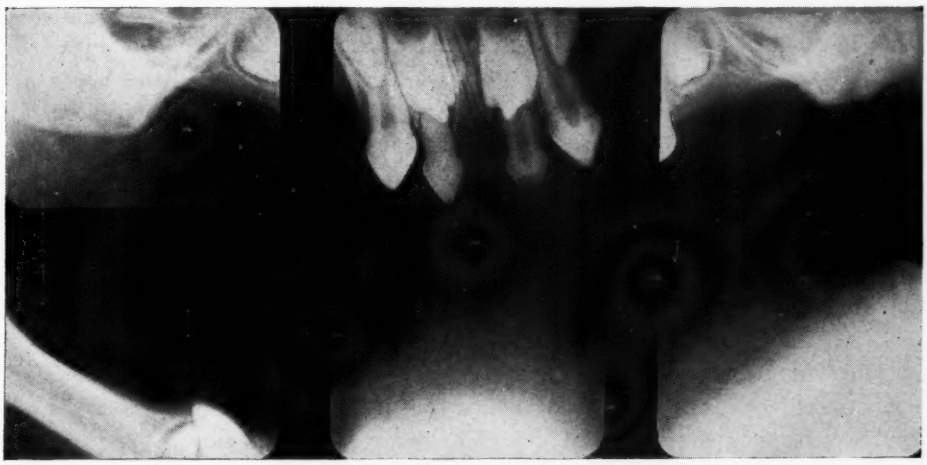

Fig. 5.

Fig. 6.

cast gold crowns having mesial and distal undercuts for retention and with a rest seat on the lingual. A lower partial and upper full denture was then constructed, using in the posterior region three bicuspids and one molar of the 20-degree type. This reduction of the occlusal surface was for the purpose of minimizing stresses on the lower knife-edge ridge. The patient had difficulty in closing in the established centric relation immediately after insertion, but after

a week this difficulty was overcome (Fig. 7). The difference in facial appearance can be comparatively appreciated by studying Figs. 1, 2, 7, 8, and 9.

PSYCHOLOGIC ASPECT

The esthetic effect of the denture prosthesis and the response of the patient were very interesting to note. The lips assumed a more pleasing position and the face developed a harmonious appearance.

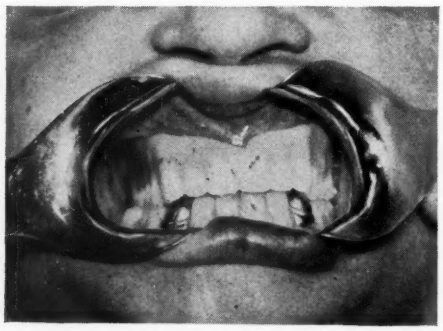

Fig. 7.

Fig. 8.

Fig. 9.

The psychologic change in the patient was tremendous; his whole personality and attitude changed. He showed a very great interest in the restorative work when the trial denture was first tested in the mouth. His immediate reaction on insertion of the finished dentures was to tightly compress his lips in an effort to hide the teeth, but later on he became less conscious of their presence. He has now started making more friends and takes a keener interest in his work.

For the prosthodontist, such cases involve an enormous outlay of time and energy. The reward comes when the operator appreciates that his efforts have made possible an entirely new life and that an individual has indeed become a personality with greater possibilities of a longer, happier, and more effective life.

DISCUSSION

Case reports of congenital ectodermal dysplasia involving various different ectodermal tissues of the body have been reported before in the literature.[1-8] Barrett[9] describes a case of inherited hypothyroidism with dystrophies of the nails and hair.

In the case described in this article, the patient exhibits characteristic deficiency of growth in practically all the ectodermal tissues, namely, the skin, hair, teeth, thyroid and the pituitary gland.

Thannhauser[10] describes a similar case of ectodermal defect in which the patient exhibited signs of insufficiency of the adrenal medulla, and in which the sweat glands started functioning scantily after the patient was 16 years of age. While the general effect of the thyroid extract on the body is well understood, its effect on the sweat glands and their activity is not understood.

As previously mentioned in Family History, the two other male children (one of whom is living) showed similar tendencies. One of the girls shows absence of two lateral incisors; the other has normal dentition. No further information could be elicited regarding other members of the family who may or may not have suffered from this anomaly.

From the history of the present generation, it appears that the condition may be sex-linked. This conclusion has also been arrived at by Roberts[11] and others.[2-5,7,8] Quoting Lowenburg and Grimes[12] "There is a gene mutation in the x chromosome which is sex-linked but not completely recessive." Levit[15] has claimed that it may be conditionally dominant in some families so that heterozygous females might have the dysplasia but in a milder form. Weech's[16] idea is that all the cases do not go back to one individual but there may occur mutations in the genes of any particular individual regardless of sex. Thus both sexes may be affected. Thereafter the transmission would be sex-linked and the anomalies appear only in the male. Weech believes that this explains the occasional occurrence of the conditions in the females. "Manifestation of the syndrome in the female is not a fatal objection to the hypothesis according to Grant and Falls,[6] as discrepant males also have occurred in the pedigrees of other traits known to be sex-linked in inheritance."

The peculiarity of the selectivity and extent of the tissues affected cannot be fully explained. It is possible that growth retardation is affected at a specific period of the histodifferentiation of certain tissues. The teeth may be affected due to suppression of development of the tooth buds during initiation in the sixth week of the embryonic life.[17] In its most severe form, it may result in total aplasia of the dental lamina and complete absence of tooth development. It is also possible that ectodermal development may be affected later in fetal life, when the dental lamina may have formed and produced buds for the enamel organ of the deciduous teeth. The effort to form the deciduous buds may consume the entire genetic force with the result that the anlage for the permanent teeth will fail.[1]

Partial anodontia, affecting both deciduous and permanent dentitions, in some instances can be explained where the genetic force is first consumed in producing the first few deciduous teeth having the same initiation period (the anterior teeth) and later revival of enough genetic force to produce buds

for a few of the permanent dentition. This could explain the presence of first molars and anterior teeth in the present case. This theory could also explain various syndromes which result from the involvement of different tissues of ectodermal origin during their histodifferentiation after the second month of embryonic life.[7]

According to Schour and Massler,[13] "The effect of a deficiency in the secretion of thyroxine, the active ingredient of the thyroid hormone, is to depress markedly the basal metabolic rate of cellular metabolism. As a result, growth virtually stops in almost all tissues. Certain tissues are more severely affected than others, the degrees depending on the rate of growth at the time of disturbance."

The condition of congenital hypothyroidism may also be related to abnormal thyroid function of the mother during pregnancy. As cited by Marinus,[14] "It is probable that the baby will be born with an abnormally functioning thyroid gland when the mother's thyroid function during pregnancy is abnormal."

The effect of the dentures on the growth of the maxilla and mandible will be interesting to observe. Theoretically, further growth of the maxilla would be retarded by the upper denture while the growth in the mandible will continue, and, therefore, the dentures may require frequent change.[6]

We are very grateful for and wish to acknowledge assistance rendered by the staff of the Glandular Clinic of the Detroit Public Schools in compiling this report.

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Paragraph Clinics

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AN ACCURATE ALGINATE MODEL OF THE TISSUE SIDE OF AN IMMEDIATE DENTURE

ARVIN WILLIAM MANN, D.D.S.

Fort Lauderdale, Fla.

SURGEONS frequently use an alginate model of the tissue side of an immediate denture as a guide to determine the amount of trimming necessary during alveolectomy. A mix of alginate is placed *inside* the denture and over the top or *outside* of a perforated tray. A wet 6-inch No. 2 cotton roll is embedded in the alginate over the ridge area, and the denture is seated on the tray. After setting, the alginate model is separated from the denture. It will be an accurate reproduction of the inside of the denture.

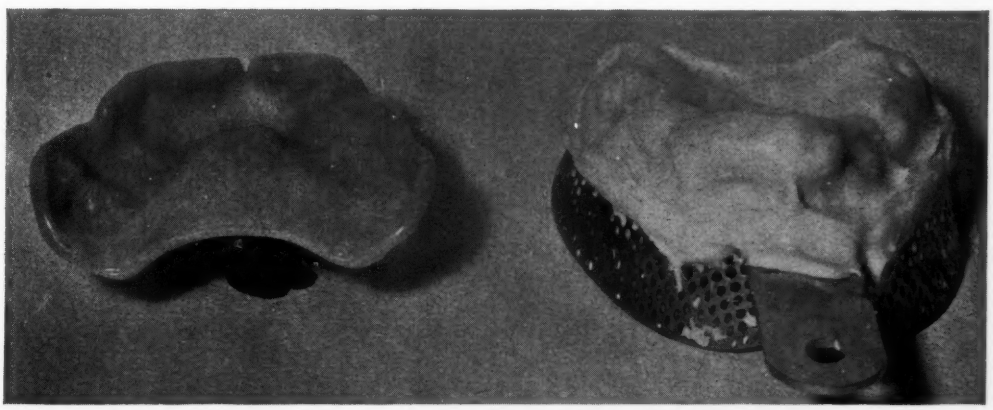

Fig. 1.—Left, The immediate denture. Right, The alginate model of the tissue side of the denture.

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News and Notes

Founded in Paris on May 2, 1951, by Drs. Cauhépé (France), de Coster (Belgium), Dreyfus (Switzerland), Hoffer (Italy), and Korkhaus (Germany), THE INTERNATIONAL CLUB OF FACIAL MORPHOLOGY has been constituted in Lausanne on Sept. 3, 1951, in the presence of Mr. Paul Berger, a lawyer, with Dr. Dreyfus in the chair.

Its only object is the scientific study of the morphology of face and skull; its members are chosen by the founder-members, with no regard to frontiers.

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